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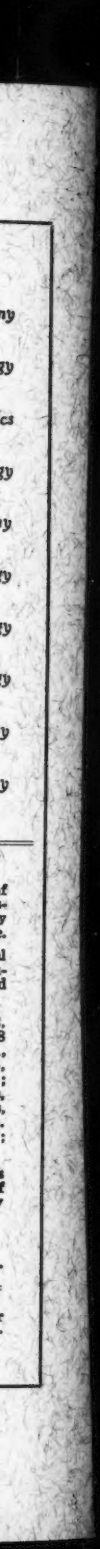

The American Midland Naturalist

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Taxonomic Studies of Nearctic Cryptini
(Ichneumonidae, Hymenoptera)*

Harry Davis Pratt

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Introduction

The present paper contains a generic key to the tribe Cryptini, a key to and descriptions of the Nearctic species of *Cryptus* Fabricius, a description of the new genus *Nasutocryptus*, and a bibliography of the literature on the members of the Nearctic tribe. A brief account of the biology of the Cryptini is given. A brief study has been made of the larvae of at least one species in 19 of the 31 Nearctic genera. Head structures of the larvae of 19 genera and the chaetotaxy of the larvae in 16 genera have been figured to illustrate the provisional synopsis of the larvae.

Acknowledgments

The writer wishes to express his sincere appreciation to Dr. C. E. Mickel for his constructive criticism and valuable suggestions during the preparation of this paper. Dr. A. Roman of Stockholm, Sweden, has sent specimens of the genotypes of many Holarctic genera of Cryptinae. Mr. G. S. Walley has given valuable advice on the types in the Canadian National Collection in Ottawa and on the Provancher types in Quebec, Canada. Dr. H. K. Townes has assisted in many ways by loaning homotypes and specimens of many of the species of Cryptini and by correspondence on many difficult problems. Mr. R. A. Cushman of the U. S. National Museum has given freely of his time and advice based on a quarter of a century's work on the family throughout the course of this study. He has been of invaluable aid in making available notes on types, and especially in furnishing careful and constructive criticism of generic and specific keys.

A complete list of those who have aided in the preparation of this paper through the loan of specimens is added here. Initial letters have been used to designate institutional and private collections to conserve space in the distributional data section of this paper.

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Biology of the Cryptini

Bridgeman and Fitch (1882) noted that the ichneumon flies of the tribe Cryptini were typically "not sun-loving insects, but they are generally found at the roots of low plants or amongst dead leaves and debris in dry ditches, or at the roots of old trees, running and skipping about with their antennae rapidly vibrating; they seem very partial to clumps of tansy and are frequently found on nettle, mint, or other leaves when covered with honey dew; a few of the larger species of *Cryptus* are, however, found on the blooms of *Pastinaca, Angelica,* and other Umbelliferae."

A great variation occurs in the method of oviposition. The parasite egg may be laid on the host egg, as in *Hoplocryptus graenicheri* (Viereck); on the larvae, as in *Hoplocryptus, Cryptus,* and many other genera; on prepupae, as in *Agrothereutes abbreviator* (F.) and *Agrothereutes neodiprionis* (Cushman); or in true pupae as in some species of *Cryptus* and *Ischnus.*

The larvae feed on a remarkable variety of hosts. In general Cryptine larvae are ectoparasites of larvae and prepupae; but if they feed on pupae, as some species of *Cryptus* and *Ischnus,* they are endoparasites. Careful study of the host-parasite relationships and the larval ecology will undoubtedly indicate

certain natural groups of genera of great value in any phylogenetic arrangement of the tribe.

Thus, the more primitive genera such as *Echthrus* Gravenhorst, *Helcostizus* Forester, *Cryptohelcostizus* Foerster, *Agonocryptus* Cushman, *Xylophrurus* Foerster, and *Mallochia* Viereck have a peculiar, apically impressed or dentate clypeus, a first abdominal segment with the spiracle before or nearly in the middle, and females with strongly inflated anterior tibia and long seventh tergite. Larvae of these genera are solitary, external parasites of wood-boring Coleoptera and Lepidoptera, such as Buprestidae, Cerambycidae, Scolytidae, and Aegeriidae.

Acroricnus Ratzeburg, *Photocryptus* Viereck, and *Messatoporus* Cushman form a homogeneous group of genera whose adults are very distinct in long, slender mandible and abdominal petiole. Their larvae are parasites of Hymenoptera which build mud daubs, such as *Pseudogenia, Eumenes,* and *Sceliphron.*

Crypturopsis Ashmead, *Polycrytus* Spinola, *Derocentrus* Cushman, and *Mesostenus* Gravenhorst were formerly classified in the tribe Mesostenini because the adults have a small alar areolet. The larvae are parasites of Pyralididae and Tortricoidea.

The larvae of species of *Idiolispa* Foerster, *Trychosis* Foerster, and of *Diapetimorpha orba* (Say) are solitary parasites or predators in spider egg sacs. The larvae of a Neotropical species of *Acerastes* are gregarious parasites in spider egg sacs.

Compsocryptus retentor (Brulle) has been reared from a Megalopygid cocoon.

Chromocryptus planosae (Fitch) may be a polyembryonic ichneumonid. The type series consisted of five females reared from a single comoon. Another series consisted of 22 females reared from one host cocoon, while a third series was made up of one small male and five dead males, still enclosed in their respective cocoons, inside the host cocoon. These data suggest that a single egg is laid by the parasite and that the gregarious larvae arise by polyembryonic development similar to that occurring in the Braconid genus *Macrocentrus.*

Larvae of *Ischnus* Gravenhorst (*Habrocryptus* Thomson) are typically internal parasites of larvae, prepupae, and pupae of Lepidoptera and Diprionidae.

Species of *Hoplocryptus* Thomson have been reared from a number of twig-boring and leaf-rolling Lepidoptera, Coleoptera, and Hymenoptera. Rearing records of such species as *H. bituminosus* (Cushman) and *H. longicornis* (Prov.) indicate that the oviposition stimulus is not a specific host, but merely a larva, prepupae, or pupa inside a stem or rolled inside a leaf.

Larvae of *Gambrus* Foerster are gregarious parasites of prepupae or pupae of Saturniidae, Liparidae, or Lasiocampidae.

Agrothereutes Foerster is the only known genus in the Cryptini to have brachypterous females and macropterous males in the same species. The larvae are parasites of prepupae or pupae of Cimbicidae, Tenthredinidae, and Diprionidae.

The account of the biology of *Cryptus sexannulatus* Grav. given by Rosenberg (1934) and Naphthali (1941) appears to be typical for the genus *Cryptus* Fab. The preoviposition period lasts two or more days. There are five to seven ovarioles in each ovary, each ovariole with only one mature egg. Probably not more than 3-6 eggs are laid during one day by one female. The subcylindrical eggs, 2-5 times as long as their greatest diameter, hatch in two or three days. Rosenberg noted 4-6 larval stages. The teeth on the mandibles, so characteristic of Cryptine larvae, appear in the third larval stage. By the fourth larval stage the mouth parts and supporting sclerites are well-formed and heavily chitinized. The pupal period lasts 1-2 weeks. Adult females lived 76-92 days; males, 20-42 days.

Adult *Cryptus* seem to prefer to feed on flowers of the order Umbellales because the nectar is so readily available, but they have also been collected on the flowers of Leguminosae and some western Cruciferae and Chenopodiaceae.

S. B. Doten of Reno, Nevada, supplied manuscript notes concerning the longevity of *Cryptus*, and his data have been correlated with actual specimens now in the U.S. National Museum. The following table is a tabulation of the specimens of *Cryptus* with which Doten worked. Each specimen bears a single typewritten number and this number corresponds to the number of days that the specimen lived confined in the test tube and fed honey and water, honey dew and water, or plain water.

Species of Cryptus	Number of days male lived	Number of days female lived
C. asymmetricus	108, 164	
C. dirus	113, 121, 123, 127, 160, 161, 172, 175	109, 112, 154, 163, 191
C. ocellaris		5, 5, 200
C. perplexus	23, 23, 23, 23, 47, 141, 148, 152, 155, 194, 201, 212, 232, 239	24, 24, 158, 197, 221
C. pacificus	101, 104, 110, 114, 162, 190, 197	19, 19, 19, 19, 19, 19, 95, 122, 142, 177
C. relativus	105	
C. rufopedibus		186
C. rufovinctus	14, 108, 164	192, 18.
C. strigosus		4
C. albitarsis coloradensis	151	

Because of the various conditions under which these specimens were captured, fed, and housed, no statistical analysis is warranted. Doten (in his manuscipt notes) knew that *Cryptus perplexus* could survive complete starvation for 48 hours. The average length of life in confinement of the 63 specimens of 10 species in the above table was 121 days, the shortest being 4 days, the longest 239 days. No significant difference was noted in the length of life of male or female, although the two specimens which lived 232 and 239 days respectively were both males.

The larvae of *Cryptus* are polyphagous. Individuals of *Cryptus albitarsis albitarsis* Cresson, *Cryptus luctuosus* Cresson, and *Cryptus rufovinctus* Pratt have each been reared from several different hosts (see page 24). Most *Cryptus* larvae are ectoparasites and destroy the host in the prepupal or pupal stage, but larvae of *Cryptus albitarsis* Cresson and *C. altonii* Dalla Torre are sometimes endoparasites. The European *Cryptus dianae* Gravenhorst occurs both as primary and secondary parasite of *Panolis flammea* Schiffermueller, but all other species of *Cryptus* known thus far appear to be primary parasites.

There is a rough correlation between the size of the parasite and the host upon which the parasite larva fed. Several European writers also believe that there is a correlation between the size of the host and the sex of the adult parasite. Of the specimens of *Cryptus albitarsis albitarsis* (Cresson) seen during this study, those reared from small hosts such as *Psorosina hammandi* Riley, *Grapholitha molesta* Busck, and *Archips fervida* Clemens were small males, 6-7 mm. long, while those reared from larger hosts were larger and female.

Most species of *Cryptus* are diurnal, but three species have been collected at trap lights: one male *Cryptus albitarsis coloradensis* Ashmead, a female *Cryptus persimilis* Cresson, and a female paratype of *Cryptus ruralis* Pratt

A single gynandromorph of *Cryptus pacificus* Cresson has been found during this study. One half of the head shows male characters, and the other half shows female characters. The rest of the insect is a normal female. This specimen, now in the Academy of Sciences, Philadelphia, Pa., was of great value in showing that *pacificus* Cresson and *punicus Cresson* are sexes of the same species.

Larvae of the Cryptini

Most of the larvae of the tribe Cryptini spin their cocoons inside the host cocoons or pupae and there transform into pupae and adults. As a rule the larva ejects a considerable amount of greasy, brown and black material during the change from prepupa to pupa, and this material forms a plug at one end of the cocoon. The cast exuvium of the larva is usually found adhering to this plug. On this same plug is often found the cast pupal exuvium and a small amount of white or greyish, ash-like meconium, discharged by the newly-transformed adult.

Preparations of these larval exuviae may be made by soaking them from 1-5 hours in 10% potassium hydroxide, washing in water, dehydrating in 95% alcohol, and mounting in diaphane. The head should be dissected from the rest of the exuvium and the larval integument should be split on the median line, flattened out and mounted on the same slide with the larval head.

Two rather different sets of terminology for the head of parasitic Hymenoptera have been proposed: one by Thorpe (1930) and Salt (1931) which is used by many English and Continental workers; and the other proposed by Vance and Smith (1933) and used by some American workers. Morris, Cameron, and Jepson (1937) have published observations and figured the heads of several species of Cryptini. They used the better terms of both the above-

mentioned English and American systems of terminology, and their terms, as illustrated in fig. 103, have been used in this paper.

The important tribal characters of the larvae of the Cryptini are as follows: mandible with a single, large tooth and a double row of fine teeth; labrum transverse with well-defined labral arch thickened in middle; epistoma incomplete, extending as far dorsally as interior tentorial pits, but not extending between these; labrum with 6-12 macrosetae; both maxillary and labial palpi present, and, in mature larvae, usually with two pores each; ligula well-defined; maxillary strut articulating with labial strut, and labial strut articulating with posterior half of labial arch; labium with three pairs of setae; maxillary palpus with a seta on either side; and usually one seta in angle formed by maxillary strut and hypostoma.

The synopsis of larvae in the tribe Cryptini studied by the writer is intended to point out certain significant characters by which the various Cryptine genera may be differentiated. It is based on 25 species in 19 genera and such figures and descriptions as occur in the literature. The key undoubtedly will need to be modified when material of more species becomes available.

PROVISIONAL SYNOPSIS OF SOME LARVAE IN THE TRIBE CRYPTINI

1. Labrum with 10-12 macrosetae (figs. 85-90) 2
   Labrum with 6-8 macrosetae (figs. 91-102) 8
2. Labrum with 12 macrosetae (figs. 85-86) 3
   Labrum with 10 macrosetae (figs. 87-90, 103) 4
3. Dorsal margin of labral arch with 3 thickenings; lobes of ligula strongly swollen; macrosetae of integument 6-12 times as long as spinules, figs. 85 and 104..... *Xylophrurus* Foerster
   Dorsal margin of labral arch with a single thickening; lobes of ligula slightly expanded; macrosetae of integument 4-6 times as long as spinules, figs. 86 and 105 ..... *Mallochia* Viereck
4. Spinules long, sharp, and pointed, 2-3 times as long as basal width; macrosetae of integument 2-4 times as long as spinules, figs. 103 and 106..... *Cryptus* Fabricius
   Spinules conical to papilliform, 1-2 times as long as basal width; macrosetae of integument 4-8 times as long as spinules, figs. 87-90 and 107-110..... 5
5. Spiracle with atrium 1.8-3 times as wide as trachea 6
   Spiracle with atrium 1-1.8 times as wide as trachea 7
6. Clypeus with 8 macrosetae; atrium of spiracle almost twice as wide as trachea; figs. 87, 107 ..... *Acroricnus* Ratzeburg
   Clypeus with 4-6 macrosetae; atrium of spiracle more than twice as wide as trachea, figs. 88, 108 ..... *Messatoporus* Cushman
7. Majority of spinules obconical, about as long as basal width, figs. 89 and 109 ..... *Polycyrtus* Spinola
   Majority of spinules conical, longer than basal width, figs. 90 and 110..... *Listrognathus* Tschek
8. Labral arch with three thickenings on dorsal margin, fig. 91..... *Diapetimorpha* Viereck
   Labral arch with a single thickening on dorsal margin..... 9
9. Integument with spines twice as long as spiracle 10
   Integument without such spines 11
10. Atrium of spiracle less than twice as broad as trachea, fig. 92.... *Crypturopsis* Ashmead
    Atrium of spiracle 2-3 times as broad as trachea, figs. 93 and 111..... *Mesostenus* Gravenhorst
11. Atrium of spiracle 2-3 times as broad as trachea 12
    Atrium of spiracle 1-2 times as broad as trachea 14
12. Labrum with 6 macrosetae; labial palpus with more than two pores (third instar larva), fig. 94 ..... *Acerastes* Cushman

Labrum with 8 macrosetae; labial palpus with two pores 13
13. Clypeus with 6 macrosetae; integument with many macrosetae in several species; base of labium more or less trilobed, figs. 96 and 112 ..... *Trychosis* Foerster
Clypeus with 4 macrosetae; integument with few macrosetae; base of labium simply arcuate, figs. 95 and 113 ..... *Idiolispa* Foerster
14. Spinules sharply conical, 1.5-3 times as long as basal width; macrosetae of integument 2-4 times as long as spinules, figs. 114-116 15
Spinules short, conical, or papilliform, 0.5-1.5 times as long as basal width; macrosetae of integument 3-8 times as long as spinules, figs. 117-119 17
15. Annular base of macroseta of integument 2-3 times as wide as basal width of spinule, figs. 99, 116 ..... *Agrothereutes* Foerster
Annular base of macroseta of integument 1-2 times as wide as basal width of spinule, figs. 114-115 16
16. Macroseta of integument 2-3 times as long as spinule; lobes of ligula strongly swollen, figs. 97, 114 ..... *Chromocryptus* Ashmead
Macroseta of integument about twice as long as spinule; lobes of ligula not strongly swollen, figs. 98, 115 ..... *Ischnus* Gravenhorst
17. Spinule 1-1.5 times as long as basal width, figs. 100 and 117 ..... *Hoplocryptus* Thomson
Spinule about as long as basal width, figs. 118 and 119 18
18. Ligula-salivary duct complex of normal size; labial strut with seta on lateral end; mandible twice as long as basal width; figs. 101, 118 ..... *Gambrus* Foerster
Ligula-salivary duct complex very large; labial strut without seta on lateral end, but in membrane just anterior to strut; mandible less than twice as long as basal width; figs. 102, 119 ..... *Megaplectes* Foerster

Historical Account of the Tribe Cryptini

In the Old World men who have studied ichneumon flies in the tribe Cryptini fall into three main groups. There were the pioneers who were mainly interested in describing species: Linnaeus (1758), Fabricius (1805), Thunberg (1822, 1824), Gravenhorst (1829), Ratzeburg (1844, 1848-1852), and Brulle (1846). Then came a group who founded our modern system of classification: Foerster (1850-51, 1868), Holmgren (1855), Taschenberg (1865), Thomson (1873, 1896), and Tschek (1870, 1872). Lastly, there is the modern group who have developed the present classification, starting with Schmiedeknecht (1890 to 1931), Dalla Torre (1901-1902), Morley (1907), Szepligeti (1916), Roman (1912 to date), Ceballos (1929, 1931), Seyrig (1927), and Uchida (1930 to date).

In America the same three groups may be observed. Of the pioneers group only O. Fabricius (1780), Say (1829, 1836), and Kirby (1937) need mention. In the last half of the nineteenth century Cresson (1864-1887), Walsh (1873), Provancher (1874 to 1889), Harrington (1893), and Cameron (1885 to 1908) not only described many new species, but gave workable synopses and specified keys to many species of Cryptini. The modern group, Ashmead (1890 to 1902), Viereck (1903 to 1924), Cushman (1915 to date), Walley (1937) and Townes (1939) have added much in the way of generic classifications, specific keys or notes on particular species, host parasite relationships, and phylogenetic relationships with the rest of the family Ichneumonidae.

Of the above mentioned works the following merit special attention: Gravenhorst (1829) who did the pioneer work on the European species; Foerster (1868) who made the first important generic classification of the tribe

Cryptini; Thomson (1873) who first used the characters now employed for major generic groupings in the Cryptini; Ashmead (1900b) who directed anew the attention of entomologists to the works of Foerster and Thomson and added many exotic genera to the European classifications; Schmiedeknecht (1890 to 1931) for his comprehensive series of generic and specific keys to Old World Ichneumonidae; Szépligeti (1916) for his keys to many exotic genera throughout the world; and Cushman (1929) for his revision of the Mesostenine genera and species in the tribe Cryptini.

Terminology

The system of wing venation used in this paper is that of Rohwer and Gahan (1916). The terms are all explained in fig. 31. The terms used in the descriptions of the male genitalia follow the work of Snodgrass (1941) as shown in fig. 77.

Preparation of Male Genitalia

The male genitalia show very few characters unless special preparations are made. The tip of the abdomen was snipped off at about the seventh tergite, and soaked from five to thirty hours in cold, ten per cent potassium hydroxide. Then, the subgenital plate and syntergites could be dissected away, the genitalia split on the mid-ventral line and flattened out. The aedeagus was dissected out and flattened, and the volsellar plate (which is often bent so that the digitus and cuspis come to lie between the volsellar plate and the paramere) was straightened out. These parts were then dehydrated and hardened in alcohol, cleared in xylol, and mounted in balsam. Each slide bears the same number as a small label pinned with the specimen. The important taxonomic characters appear to be the shape of the subgenital plate, paramere, and cuspis, and, to a lesser extent, of the aedeagus.

Tribe Cryptini

Cryptini Ashmead, Proc. Ent. Soc. Wash., 1894, 3:278.

The ichneumon flies included in the present tribe Cryptini have been grouped under a great variety of supergeneric names. Kirby (1837) first called it a family Cryptidae; Holmgren (1855), the Crypti; Taschenberg (1865) and many later authors, the Cryptides; Foerster (1868), the Cryptoidae; and Thomson (1873), the Cryptina. Ashmead (1894) first gave it the modern Cryptini but he later (1900a) divided the tribe on the basis of the size of the alar areolet into two tribes: Cryptini and Mesostenini. Later workers have generally recognized these two groups, either as tribes Cryptini and Mesostenini, or as subfamilies Cryptinae and Mesosteninae. After Morice and Durrant (1914) published their paper in the Erlangen list, many thought that the generic name *Cryptus* could no longer be used in the family Ichneumonidae. Consequently Viereck (1918) proposed the subfamily Osprynchotinae and Bradley (1919), the Hedycryptinae.

Many authors have placed *Helcostizus* Foerster and *Echthrus* Gravenhorst in the tribe Xoridini in the subfamily Pimplinae because the first segment is

subpetiolate with the spiracle at or before the middle, whereas typical Cryptinae have the abdomen petiolate with the spiracle distinctly behind the middle of the first segment. Cushman (1919b and 1929) has noted that *Echthrus* Gravenenhorst, *Helcostizus* Foerster, *Cryptohelcostizus* Cushman, and *Xylophrurus* Foerster form a connecting link between the subfamilies Pimplinae and Cryptinae "not exactly referable to any at present recognized tribe in either subfamily," but Cryptinae rather than Pimplinae. These genera all have the clypeus medially dentate or apically inflexed in both sexes. The females of these genera all have strongly inflated anterior tibiae, truncate apical segment of antenna, and long seventh tergite. These genera, with tropical genera such as *Digonocryptus* Viereck, *Perosis* Foerster, and *Nesolinoceras* Ashmead, make up a vast complex intermediate between Xoridini and Cryptini which it seems wisest to place in the tribe Cryptini on the basis of the well-defined sternaulices, bilobed fourth tarsal segment, and the previously mentioned clypeal, tibial, and abdominal characters.

The tribe Cryptini intergrades in propodeal characters almost imperceptibly with the tribe Phygadeuonini. It is customary to say that the propodeum of Cryptini is not completely areolated, entirely without median longitudinal carinae, while that of the Phygadeuonini is completelv areolated. Some species of *Compsocryptus* Ashmead and *Opisoxestus* Ashmead do have the propodeum entirely without carinae, but most genera have one or two transverse carinae. In addition some Cryptini, including some species of *Cryptus* (s. str.) have median longitudinal carinae defining a trapezoidal, median basal area between the base of the propodeum and the basal transverse carina. Median longitudinal carinae are sometimes present in the petiolar area also. The median longitudinal carinae, however, are usually absent between the basal and apical transverse carinae.

Certain genera in the tribe Phygadeuonini, such as *Aptesis* Foerster and *Chaeretymma* Foerster, have often been confused with the Cryptini. The propodeal carinae in these genera are rather weak, and have caused these genera to be placed in the Cryptini. The presence of an inclivous nervellus will serve to place these genera in the tribe Phygadeuonini, rather than in the Cryptini. Most Cryptini have a perpendicular or reclivous nervellus, but this character is not invariable in the tribe, as for example in *Helcostizus* Foerster, *Polycyrtidea* Viereck, or a number of tropical Cryptine genera.

Tribal characters.—Medium to large species with the mesosternum separated from the mesopleurum by a distinct groove or sternaulus; propodeum not completely areolated, but usually lacking the median longitudinal carinae between the basal and apical transverse carinae; stigma long and lancoelate; areolet pentagonal or quadrangular (at lest by position), second intercubitus often absent; nervellus usually reclivous; fourth tarsal segment, especially in females, bilobed; first segment of abdomen subpetiolate, to distinctly petiolate, spiracle varying in position from slightly before middle to well behind middle; gastrocoeli usually absent on second tergite; ovipositor rather conspicuously exserted; male subgenital plate with a membranous flap on inner surface on posterior half; ninth and tenth tergites united laterally to form syntergites.

KEY TO THE NEARCTIC GENERA IN THE TRIBE CRYPTINI

1. Brachypterous ..... some females of *Agrothereutes* Foerster
   Macropterous 2
2. First abdominal segment subpetiolate, stout, spiracle at or before middle 3
   First abdominal segment distinctly petiolate, spiracle (except in *Messatoporus* in which the petiole is long and slender) distinctly behind middle 6
3. Nervellus strongly inclivous, broken below middle (fig. 1); body sculpture largely finely granulate ..... *Helcostizus* Foerster
   Nervellus perpendicular or reclivous, never inclivous; body sculpture coriaceous to rugose, that of abdomen less strongly so than of thorax 4
4. Sternaulices absent (fig. 2) ..... *Cryptohelcostizus* Cushman
   Sternaulices present 5
5. Gena in lateral view much shorter than compound eye; areolet small, parallel-sided, first abscissa of radius much more than five times length of first intercubitus; ovipositor shorter than abdomen; fig. 3 ..... *Agonocryptus* Cushman
   Gena in lateral view subequal in length to compound eyes; areolet large, pentagonal, anteriorly convergent, first abscissa of radius always less than five times length of first intercubitus; ovipositor subequal to, or longer than abdomen; fig. 4 ..... *Echthrus* Gravenhorst
6. With the following characters in combination: clypeus apically dentate; spiracle of first abdominal segment only slightly behind middle; areolet small, pentagonal, anteriorly convergent (at least by position) 7
   Not agreeing entirely with all the above characters 9
7. Areolet complete, second intercubitus present; first tergite with dorsal carinae present, especially in female; fig. 5 ..... *Xylophrurus* Foerster
   Areolet incomplete, second intercubitus entirely absent or indicated only by bullae; first tergite entirely without dorsal carinae in both sexes 8
8. Clypeus arcuately truncate, more or less distinctly toothed medially; propodeum with basal transverse carinae only; mandibles suspended normally, almost transverse when closed; fig. 6 ..... *Mallochia* Viereck
   Clypeus strongly elevated and elongate, drawn out ventrally into an acute projection; propodeum with both basal and apical transverse carinae, apical carina laterally produced into short, lamellate apophyses; mandibles suspended diagonally, meeting at an acute angle when closed ..... *Nasutocryptus* n. gen.
9. Mandible long and slender, distally very narrow, about three times as long as wide at base, lower tooth much shorter than upper, even entirely absent in some cases; (first abdominal segment long and slender, decurved in both sexes, only slightly broader than petiole) 10
   Mandible broader, less than three times as long as wide, teeth usually subequal, or if with the upper tooth longer, then post-petiole is wider than petiole 12
10. First abdominal segment with spiracle in middle; areolet open on outer side, and very small, first abscissa of radius about 7 times as long as first intercubitus; fig. 7 ..... *Messatoporus* Cushman
    First abdominal segment with spiracle definitely behind middle; areolet closed and large, first abscissa of radius not more than 4 times as long as first intercubitus 11
11. Nervellus broken distinctly below middle and perpendicular; eyes parallel within, not emarginate; propodeum with petiolar area coarsely, transversely rugose; hind tarsus without two pairs of strong spurs in middle of last segment; fig. 8 ..... *Photocryptus* Viereck*
    Nervellus broken above middle and reclivous; eyes convergent below and emarginate opposite or slightly above antennal foramina; propodeum with petiolar area at most finely rugose; last segment of hind tarsus with two pairs of spurs in middle; fig. 9 ..... *Acroricnus* Ratzeburg
12. Second discoidal cell neither pointed nor strongly narrowed at base, figs. 10-15, 18-30 13
    Second discoidal cell pointed or very narrow at base, figs. 16 and 17 19

* The species of *Photocryptus* are all neotropical.

13. Areolet small, first abscissa of radius 5-6 times as long as first intercubitus, areolet longer thaan wide or with second intercubitus obsolete 14
Areolet usually larger, with first abscissa of radius less than five times as long as first intercubitus, as wide as, or wider than long (in *Listrognathus* first abscissa of radius is 5-6 times as long as first intercubitus, but then areolet is as high as long, and abdomen is very coarsely punctate) 20
14. Postpetiole in female broad, sternite not or barely reaching spiracles; in male sternite rarely reaching beyond spiracles and then only slightly beyond; submediellan cell distinctly arched above 15
Postpetiole in female narrow, sternite reaching distinctly beyond spiracles, in male far beyond; if not so, areolet is very long and narrow; subediellen cell straight or very slightly arched above 17
15. Areolet pentagonal in position, open at apex, intercubiti convergent, cubitus bent forward at recurrent and backward at second intercubitus, recurrent at or before middle of areolet, fig. 10 ..... *Diapetimorpha* Viereck
Areolet elongate or quadrate, sometimes open at apex, intercubiti parallel, recurrent usually closer to second intercubitus (or its normal position) than to first, cubitus beyond recurrent straight or nearly so 16
16. Frons mutic; fig. 11 ..... *Crypturopsis* Ashmead
Frons bicornute; fig. 12 ..... *Cryptanura* Brulle
17. Frons with a stout horn; fig. 15 ..... *Polycyrtus* Spinola
Frons unarmed, but frequently with a median carina that, seen from above, may appear as a small horn 18
18. Hind trochantella much longer than trochanter; ovipositor much longer than body; fig. 13 ..... *Derocentrus* Cushman
Hind trochantella not longer than trochanter; ovipositor shorter than body; fig. 14 ..... *Mesostenus* Gravenhorst
19. Frons with a single, stout horn; areolet not defined; second intercubitus and recurrent very close together; nervellus inclivous; fig. 16 ..... *Polycyrtidea* Viereck
Frons mutic; areolet pentagonal in position, second intercubitus missing, cubitus subobsolete beyond recurrent; nervellus reclivous, fig. 17 ..... *Acerastes* Cushman
20. First segment of abdomen without carinae, subcylindrical, sternite fused indistinguishably with tergite; postpetiole cylindrical, not much broader at apex than at base (notaulices strongly impressed, wings fuscous, areolet subquadrate, ramellus absent) ..... *Joppidum* Cresson
First segment of abdomen with dorsal or lateral carinae, or both; sternite distinct from tergite; postpetiole, especially in females, distinctly broader than petiole 21
21. Second segment of maxillary palpus strongly, triangularly enlarged; gastrocoeli on second tergite deeply impressed; antenna in both sexes with white annulus and in female incrassate; fig. 19 ..... *Megaplectes* Foerster
Second segment of maxillary palpus not strongly, triangularly enlarged; gastrocoeli not impressed; antenna usually without white annulus and not incrassate 22
22. Mesothorax much thicker anteriorly than posteriorly, usually mesoscutum not declivous in front (except in *Hidryta*); propodeum short, not so long as wide; first abdominal segment very long and slender, postpetiole sometimes expanded in females, in lateral view with ventral margin straight or slightly decurved 23
Mesothorax subcylindrical, mesoscutum always declivous anteriorly; propodeum longer, as long as wide; first abdominal segment shorter and stouter, usually with postpetiole distinctly curved 25
23. Notaulices well-defined on disc of mesoscutum; eyes slightly convergent below; fig. 20 ..... *Hidryta* Foerster
Notaulices weakly impressed or entirely absent on disc of mesoscutum; eyes parallel within 24
24. Nervulus antefurcal to interstitial; prepectoral carina complete, attaining subalar tubercle; epomia absent; fig. 21 ..... *Idiolispa* Foerster
Nervulus postfurcal to interstitial; prepectoral carina extending 0.5-0.6 distance from sternaulus to subalar tubercle; epomia sharply defined above, weak below; fig. 22 ..... *Trychosis* Foerster

25. Submediellan cell straight or very slightly arched above, as wide as, or wider at apex than at any point before nervellus; propodeum with apical transverse carina stronger than basal transverse carina, when carinae are present.....26
Submediellan cell distinctly arched above, wider a short distance before nervellus than at nervellus; propodeum with basal transverse carina stronger than apical transverse carina, the latter often interrupted medially and indicated laterally only by apophyses 27
26. Notaulices strongly impressed, extending posteriorly at least to a line drawn through middle of tegulae; discocubitus angulate, usually with ramellus present, fig. 24 .....*Cryptus* Fabricius
Notaulices entirely absent, or weakly impressed, never extending posteriorly beyond a line tangential to anterior margin of tegulae; discocubitus not angulate, ramellus entirely absent fig. 23 .....*Compsocryptus* Ashmead
27. Areolet strongly convergent anteriorly and rather small, first abscissa of radius 4-6 times as long as second abscissa of radius; last tergites narrowly margined with white posteriorly or unicolorous throughout.....28
Areolet parallel-side, or very slightly, anteriorly convergent; areolet typically large, first abscissa of radius 2-4 times as long as second abscissa of radius, or if longer, clypeus has a median tooth; last tergites, especially in females, often with a large white spot 30
28. Areolet small, first abscissa of radius 5-6 times as long as first intercubitus; frons with a strong horn; fig. 26 .....*Listrognathus* Tschek
Areolet larger, first abscissa of radium 2-4 times as long as first intercubitus; frons mutic 29
29. Propodeum nearly completely areolated, apical carina dentate, propodeal spiracle short and oval; nervellus broken far below middle and slightly inclivous; abdomen coarsely and densely punctate; fig. 25.....*Chromocryptus* Ashmead
Propodeum with only basal transverse carina strong, apical carina when present weak and represented only laterally; propodeal spiracle circular; nervellus broken slightly below middle and reclivous; fig. 27.....*Ischnus* Gravenhorst
30. Hind femur stout, 2-4 times as long as high in female, 5 times as long as high in male .....*Pycnocryptus* Thomson
Hind femur more slender, 5-7 times as long as high in both sexes 31
31. Clypeus medially angulate or toothed on apical margin; fig. 28.....*Hoplocryptus* Thomson
Clypeus truncate, or arcuate, without conspicuous apical tooth or angulation.....32
32. Mesoscutum opaque, thickly and finely punctate; hind tibia without basal annulus; ramellus absent; fig. 29. .....*Gambrus* Foerster
Mesoscutum more or less shining; hind tibia typically with white basal annulus; ramellus usually present; fig. 30.....*Agrothereutes* Foerster

Nasutocryptus, new genus

Head transverse, strongly narrowed behind eyes; occiput deeply and angularly concave; genae convex, strongly receding, much shorter than eyes: occipital carina complete, joining hypostomal carina distant from base of mandible; eyes very large, bulging, not at all emarginate; frons mutic and slightly excavated behind antenna foramina; mandibles suspended diagonally, teeth subequal; clypeus very strongly elevated, drawn out apically into an acute projection which extends ventrally farther than the ventral margin of the labrum; scape obliquely truncate, flagellar segments of female slightly thicker at apex than at base (male unknown).

Thorax long, subcylindrical; notaulices strongly impressed, extending posteriorly to a line tangential to posterior margins of tegulae; sternaulices moderately strong, complete; prepectoral carina complete, attaining subalar tubercle; propodeum moderately long, basal and apical carinae complete, apical

transverse carina weak in middle, produced laterally as short, lamellate apophyses; propodeal spiracle circular.

Wings long and narrow, stigma small, radius received about in middle; areolet small, similar to that of *Diapetimorpha* Viereck, that is pentagonal in position, but open at apex, first intercubitus slightly reclivous, cubitus bent anteriorly at recurrent vein, and backwards at position of second recurrent; nervulus distinctly antefurcal; second discoidal cell half as wide at base as at apex; nervellus slightly reclivous, broken at lower third; submediellan cell strongly arched above.

Legs long and slender; hind femur shorter than hind tibia; first segment of hind tarsus subequal in length to rest of tarsus; longer calcarium of hind tibia less than half as long as first segment of hind tarsus; front tibia in female slightly constricted basally and slightly swollen in middle.

Abdomen in female broadly fusiform; first tergite strongly widened at apex, spiracle slightly behind middle; sheath of ovipositor 1.6 times as long as first tergite; ovipositor compressed, decurved dorsally, serrate only on ventral margin.

Genotype.—*Nasutocryptus nasutus* new species.

Nasutocryptus is apparently closely allied to such genera as *Diapetimorpha* Viereck, formerly classified in the tribe Mesostenini because of its relatively small, incomplete areolet. However, when a number of more fundamental characters are considered, the new genus appears to be more closely allied to *Xylophrurus* Foerster and *Mallochia* Viereck. The spiracle of the first abdominal segment is only slightly behind the middle, the propodeal spiracle is small and circular, the nervulus is distinctly antefurcal, the longer spur of the hind tibia is less than one-half as long as the first segment of the hind tarsus. The very elongate, sharply-pointed clypeus of *Nasutocryptus* is merely an exaggeration of the truncate clypeus with a median tooth of *Mallochia* or the definitely dentate clypeus of *Xylophrurus*. The incomplete areolet of *Nasutocryptus* is exactly similar to that of *Mallochia*, while in *Xylophrurus* the outer or second intercubitus usually has a large bulla foreshadowing the incomplete areolets of *Mallochia* and *Nasutocryptus*. Moreover, all three genera have species with banded wings.

Nasutocryptus nasutus, new species

Plate 12

Female.—Length 5.5 mm., antenna 5 mm., ovipositor 1 mm.

Head very finely coriaceous; ocell-ocular and post-ocellar lines subequal, 1.5 times as long as diameter of lateral ocellus; inner margins of eyes parallel; malar space 1.5 times as long as basal width of mandible; occipital carina joining hypostomal carina 1.2 times basal width of mandible from mandible; mandible twice as long as basal width; antenna 0.9 as long as body, flagellum 24-segmented, first flagellar segment 6 times as long as wide at apex, second and third segments slightly shorter, fourth segment about half as long as first flagellar segment.

Thorax shining, coriaceous; pronotum laterally slightly longitudinally rugulose; mesoscutum with notaulices sharply impressed, but not at all foveolate; scutellum sloping gradually posteriorly; sternaulus complete, deeply impressed anteriorly, not at all foveolate; speculum polished; hind femur two-thirds as long as hind tibia; propodeum finely rugulose, rugulose in petiolar area; longer spur of hind tibia 0.3 as long as hind basitarsus; fore-wing with postnervulus broken above middle.

Abdomen finely coriaceous; first tergite twice as wide as posterior margin of postpetiole as petiole; second tergite twice as wide on posterior margin as at base, as long as wide at posterior margin; third tergite slightly wider than second, almost twice as wide as long; following tergites transverse, successively shorter and narrower; sheaths of ovipositor 1.6 times as long as first tergite.

Ferruginous; antenna beyond first flagellar segment infuscate, with an incomplete white annulus on flagellar segment 6-9, very narrow orbital ring around eye, scutellum, and apex of first tergite pale yellowish-white; sheaths of ovipositor pale yellowish, tips darker.

Holotype.—Female, Alamogordo, New Mexico, May 5, 1902, probably collected by H. L. Viereck, or J. A. G. Rehn, in Academy of Natural Sciences, Philadelphia, Pa.

Paratype.—One female in poor condition. Alamogordo, New Mexico, May 5, 1902. The left antenna is entirely missing and the right antenna has only four basal flagellar segments. Both anterior tarsi and the left hind tarsus are entirely missing, also four segments of the left, middle taruss. The wings are somewhat twisted and gummed with the mounting medium. There appear to be no significant differences in coloration or sculpture between the two specimens. In the collection of the University of Minnesota, St. Paul, Minnesota.

CRYPTUS Fabricius

Cryptus Fabricius, 1805, Syst. Piez.: 70. Many species included. Genotype.—*Cryptus viduatorius* Fabricius. By designation of Curtis, 1837, Brit. Ent., **14**:668.

Meringopus Foerster (Tschek), 1868, Verh. Nat. Ver. preuss Rheinland, **25**:186. No species included. Tschek, 1870, Verh. Zool. Ges. Wien, **20**:112. One species. Genotype.—(*Cryptus recreator* Fabricius)=*Ichneumon titillator* L. (Not Thomson).

Itamoplex Foerster (Ashmead), 1868, Verh. Nat. preuss. Rheinland **25**:188. No species included. Ashmead, 1900, Smith's Insects of N. J.: 570. Three species. Genotype.—(*Cryptus americanus* Cresson)=*Cryptus albitarsis* (Cresson). By designation of Viereck, 1914, Bull. 83, U. S. Nat. Mus.: 79.

Hedycryptus Cameron, 1903, Zeitschr. Hym. Dipt. **3**:298. Genotype—*Hedycryptus filicornis* Cameron (Monobasic).

Steriphocryptus Cameron, 1903, Entomologist, **36**:233. Genotype.—*Steriphocryptus luteus* Cameron (Monobasic).

Synechocryptus Schmiedeknecht, 1904, Opusc. Ichn., **2**(6):427. Genotype.—*Synechocryptus craniensis* Schmiedeknecht (Monobasic).

Specimens of *Cryptus* Fabricius are 5-25 mm. long, with the following characters:

Head in dorsal aspect transverse, in frontal aspect usually somewhat higher than wide; occiput concave; genae usually somewhat narrowed behind eyes; ocell-ocular line varying from 0.6-2.2 times as long as diameter of lateral ocellus; eyes large and prominent, inner margins subparallel; frons shallowly or

deeply excavated, in some species with a strong vertical ridge behind each antennal foramen; clypeus with a narrow, polished, slightly reflexed margin, without a tooth on apical margin; mandible 1-2.8 times as long as basal width, apically narrowed, teeth subequal; maxillary palpus with second segment stout, but not triangularly enlarged as in *Megaplectes* Foerster, fifth segment long and slender; malar space varying from less than basal width of mandible to 2.5 times basal width of mandible; occipital carina strong, joining hypostomal carina about basal width of mandible from mandible in most species, but atrophied ventrally at point of normal junction with hypostomal carina in some species as *asymmetricus;* antennae varying from half as long to as long as body length; scape large, somewhat compressed, deeply and obliquely truncate; basal flagellar segments distinctly longer than apical flagellar segments; basal flagellar segments swollen apically in female, cylindrical in male; tyloid-bearing segments in male each with a basal emargination.

Pronotum short, with an impressed, usually subfoveolate line just below dorso-lateral margin of pronotum; epomia usually present; mesoscutum anteriorly declivous; notaulices deep and distinctly impressed, often subfoveolate, convergent posteriorly and extending typically beyond middle of mesoscutum to about a line tangential to posterior margins of tegulae; prepectoral carina well-developed, often extending from sternaulus to subalar tubercle; sternaulus rather deeply impressed, complete, and subfoveolate; scutellum flat to convex, rarely margined at base; propodeum with one or two transverse carinae, posterior carina usually stronger than basal carina, and often produced laterally into short apophyses, especially in female; a trapezoidal median basal area often present between basal transverse carina and base of propodeum; petiolar area extending anteriorly more than half the length of propodeum; propodeal spiracles elongate, oval, or even circular *luctuosus* Cresson.

Legs moderately stout; hind coxae large; femur often swollen, especially in female; fore tibia in female slightly to strongly swollen, often basally constricted; hind tibia slightly longer than hind femur, spiculose, longer tibial spur 0.2-0.5 as long as first segment of hind tarsus; tarsus, especially anterior tarsus in females, often much expanded and bilobed; claw finely pectinate at base in both sexes, more strongly so in female than in male.

Stigma moderately long and narrow; marginal cell long, radius apically inflexed; areolet moderately large, intercubiti subparallel, or anteriorly convergent, rarely contiguous on anterior margin; second recurrent vein received about in middle of areolet; discoidal cell not strongly narrowed at base; discocubitus angulate, typically with a distinct ramellus; nervulus antefurcal to insterstitial postnervulus with subdiscoideus arising below middle; hind wing with nervellus broken far below mieele, reclivous, upper abscissa meeting at an acute angle; hamuli 8-15 in number.

Abdomen finely coriaceous to polished, fusiform in female, more slender in male; first segment distinctly petiolate, spiracle distinctly behind middle; postpetiole usually three times as wide as petiole in female and about twice as wide as petiole in male; second tergite with spiracle at or behind middle, epipleura very narrow; last tergite without a white spot; ovipositor sagittate, scimitar-shaped, or decurved dorsally; sheaths of ovipositor one-third as long

as, to longer than abdomen; male genitalia as in fig. 77; subgenital plate with a pad on inner face on posterior half, indicated in drawings by a dotted line; ninth and tenth tergites fused laterally to form syntergites.

Meringopus Foerster and *Synechocryptus* Schmiedekneck were proposed for female specimens with symmetrically or asymmetrically lobed anterior tarsal segments respectively. These tarsal characters are unisexual. Male specimens cannot be distinguished with certainty from other species of *Cryptus* in which the female tarsus is normal. For this reason these two genera are placed in the synonymy of *Cryptus* Fabricius.

Viereck (1914) gives *Cryptus palmipes* Kokujev as genotype of *Meringopus* Foerster. Actually Tschek (1870) stated that *Cryptus recreator* Fabricius belongs to *Meringopus* Foerster. The genus is therefore monobasic, with *Cryptus recreator* Fabricius as genotype. But, Roman (1931) has shown that the lectotype of *Ichneumon titillator* Linnaeus (1758) is a male of *Cryptus recreator* Fabricius (1805). Therefore, the genotype of *Meringopus* Foerster becomes, through synonymy, *Ichneumon titillator* Linnaeus (not Thomson) and the genotype of *Goniocryptus* Thomson (which is a synonym of *Trychosis* Foerster) becomes *Ichneumon titillator* Thomson (not Linnaeus).

Cushman (1925) has shown that the genotypes of *Cryptus* Fabricius and *Itamoplex* Foerster, *viduatorius* Fabricius and (*vinctus* Say) = *albitarsis* Cresson respectively, are congeneric. Both genotypes belong in the group of relatively small species characterized by the strongly, anteriorly convergent areolet, a second recurrent vein which is straight on the posterior half and distinctly curved on the anterior half, and a well-developed ramellus.

Hedycryptus Cameron and *Steriphocryptus* Cameron were proposed in 1903 for Oriental species of *Cryptus* (*sensu lato*). Both Schmiedeknecht (1908: 22) and Morley (1914a: 25) consider these genera to be synonyms of *Cryptus* Fabricius. It should be noted, however, that in lacking a ramellus these two genera are very close to *Compsocryptus* Ashmead, but in their possession of well-defined notaulices and propodeal apaphyses they are better placed as synonyms of *Cryptus* Fabricius.

THE NOMENCLATORIAL STATUS OF CRYPTUS

The nomenclatorial problem of the generic name *Cryptus* is rather involved. Hymenopterists have believed for over a century that the Ichneumonid genus *Cryptus* Fabricius dated from 1804 and the Tenthredinoid genus *Cryptus* Jurine dated from 1807. The Ichneumonid genus *Cryptus* Fabricius thus apparently had priority by three full years, and an enormous literature with over a thousand species of *Cryptus*, a tribe Cryptini, and a subfamily Cryptinae has arisen in the family Ichneumonidae.

Morice and Durrant (1914, 1916) published and discussed in great detail the long-forgotten "Erlangen List" of 1801 of Panzer and Jurine. They showed that the first publication of the generic name *Cryptus* was in the "Erlangen List" in 1801 for a genus of sawflies. The first species of sawfly to be described in the genus *Cryptus* was *Cryptus segmentarius* Panzer in the "Fauna Insectorum Germania Initia." Sherborn (1930: 5844) gives 1802 as the date of

publication of *Cryptus segmentarius* Panzer, while Saunders (1888) and Morice and Durrant (1916: 355) give 1804. Either date for the publication of the plate of *Cryptus segmentarius* Panzer precedes the date of publication of the Ichneumonid genus *Cryptus* Fabricius as explained in the next paragraph.

Richards (1935: 144) has done some careful research on the date of publication of Fabricius' "Systema Piezatorum." He wrote that "there is little doubt that the 'Systema' was really published early in 1805," not in 1804 as given on the title page of the "Systema." The Ichneumonid genus *Cryptus* Fabricius (1805) is therefore clearly a homonym of the sawfly genus *Cryptus* Panzer as typified by *Cryptus segmentarius* Panzer (1802 or 1804).

As soon as Morice and Durrant (1914) showed that the genus *Cryptus* Fabricius was preoccupied, a number of suggestions were made as to the correct generic name to use to replace *Cryptus* Fabricius. These names naturally fall into two groups: i.e., the earliest name *in the tribe* Cryptini, and the earliest *synonym of the genus Cryptus* Fabricius.

The generic names in the tribe Cryptini which have been used to replace *Cryptus Fabricius* (preoccupied) are *Agrothereutes* Foerster (1850) by Viereck (1916) and *Osprynchotus* Spinola (1840) by Viereck (1918). Cushman (1928) has suggested that if the tribal name Cryptini is not used, the tribal name should be Mesostenini from the oldest genus in the tribe, namely *Mesostenus* Gravenhorst (1829).

The synonym *Hedycryptus* Cameron (1903) was used by Bradley (1919) to replace *Cryptus* Fabricius (preoccupied) and Bradley suggested in a footnote in Leonard (1928) that, "If the Erlangen is accepted, this tribe (Cryptini) should be known . . . as Itamoplegini, from *Itamoplex* Foerster, replacing the homonym *Cryptus* Fabricius."

An attempt was made in 1939 to conserve certain well-known genera in the order Hymenoptera. The International Commission on Zoological Nomenclature published Opinion 135 which clearly stated "The so-called 'Erlangen List' is to be treated as though it had never been publishd." The suppression of the "Erlangen List" of 1801 does free *Cryptus* Fabricius (1805) from becoming a homonym of *Cryptus* Panzer and Jurine (1801), but it still leaves *Cryptus* Fabricius (1805) as a homonym of *Cryptus* Panzer (1802 or 1804).

The sinking of the generic name *Cryptus* Fabricius because it is a homonym of *Cryptus* Panzer will clearly result in greater confusion than uniformity if strict priority and application of the Rules are followed. The present writer will present to the International Commission on Zoological Nomenclature a petition asking that the genus *Cryptus* Fabricius with the genotype *Cryptus viduatorius* Fabricius be placed on the list of *nomina conservanda*. This placing of *Cryptus* Fabricius on the list of *nomina conservanda* will obviate the necessity of using another generic name for hundreds of species of *Cryptus*, for the tribe Cryptini, and the subfamily Cryptinae.

KEY TO THE NEARCTIC SPECIES OF CRYPTUS FAB.

1. Malar space at least twice as long as basal width of mandible (fig. 74); (Boreal species: black, with erect black pubescence, legs beyond coxae, and abdomen, reddish) ..... *arcticus* Schiodte

Malar space less than twice as long as basal width of mandible 2

2. Genae very coarsely punctate, appearing irregularly, diagonally striate in some lights (Black species with hind femur only reddish. Alberta to Arizona, west to Pacific Coast) ..... *genatus* n. sp.

Genae smooth, coriaceous, or punctate, but never strongly and coarsely punctate or irregularly striate 3

3. Mesoscutum dull, confluently rugulose especially along notaulices and lateral margins of mesoscutum; flagellum with annulus centering on segments 4-5 when annulus is present 4

Mesoscutum polished and punctate, never rugulose; female flagellum typically without annulus, but, if present, centering on segments 6-8 6

4. Coxae and trochanters reddish ferruginous ..... *rugosiscutum* n. sp.

Coxae and trochanters black 5

5. Hind femur reddish-ferruginous; female flagellum with incomplete pale annulus on segments 4-5 ..... *crassisculptus* n. sp.

Hind femur black; female flagellum black ..... *flagellatus* n. sp.

6. With the following characters in combination: propodeal spiracle circular or short oval, less than 1.5 times as long as wide; black species 6-12 mm. long with reddish hind femora 7

Propodeal spiracle usually more than 1.5 times as long as wide, but if 1.5 times as long as wide, insect does not agree entirely with above description 8

7. Hind femur entirely reddish (rarely tipped with black, but with the following characters); female with first tergite less than twice as long as wide at apex; facial orbits whitish opposite antennal foramina; basal flagellar segment in female 4 times as long as wide; ovipositor sheaths shorter than tergites 2-4 ..... *luctuosus* Cresson

Hind femur reddish tipped with black; female with first tergite more than twice as long as wide at apex; faciial orbits black opposite antennal foramina, whitish opposite frons; basal flagellar segment in female 5-6 times as long as wide; ovipositor sheaths longer than tergites 2-4; (male with white scutellum) ..... *iroquois* Viereck

8. Second recurrent vein straight or simply arched; areolet in commoner species large with intercubiti subparallel or slightly convergent, figs. 38-42 9

Second recurrent vein straight on posterior half, distinctly curved on anterior half; areolet with intercubiti strongly anterior convergent, figs. 31, 43, and 44 36

9. Paramere of male genitalia with apical margin simply arcuate (figs. 53, 54, 57-67); female with first flagellar segment 2.5-6.5 times as long as wide 11

Paramere of male genitalia with apical margin strongly angulate and with a tooth-like pade near angulation (figs. 55, 56); female with first flagellar segment 6.5-9 times as long as wide 10

10. Hind coxae and trochanters black; Alaska to Labrador, south to Cal., New Mex., and New York ..... *altonii* D. T.

Hind coxae and trochanters reddish-ferruginous; confined to Cal., Nev., Or., Wash. and B. C. ..... *perplexus* Cresson

11. Notaulices weakly impressed on disc of mesoscutum; female with first flagellar segment 2.5-4 times as long as wide and hind femur 3-4 times as long as high 12

Notaulices strongly impressed on disc of mesoscutum; female with first flagellar segment 4-6.5 times as long as high 14

12. Entire insect largely ferruginous; sheaths of ovipositor as long as abdomen beyond first tergite ..... *crassifemur* n. sp.

Head and thorax black; legs and abdomen reddish-ferruginous; sheaths of ovipositor as long as tergites 2-4 or 2-5 13

13. Gena flat; propodeal spiracle 2.5-3 times as long as wide; female with pleura longitudinally rugose and first flagellar segment 3.5-4 times as long as wide ..... *strigosus* n. sp.

Gena convex; propodeal spiracle twice as long as wide; female with pleura punctate and first flagellar segment 2.5 times as long as wide ..... *crassipes* n. sp.

14. Female only known; flagellum 29-segmented with a complete, white annulus extending from segment 3-10; anterior tibia strongly swollen in middle, figure 45 ..... *crassulus* n. sp.

Female without white annulus on flagellum, flagellum 30-55-segmented; anterior tibia not strongly swollen in middle 15

15. Face in female 2.2-3, in male 1.8-2.6, times as wide as high (fig. 76); mesoscutum highly polished, in female with punctures sparse and widely separated, in male with punctures more numerous; ovipositor decurved dorsally, entirely without dorsal angulation or tiny notch in angulation (fig. 83) 16

Face in female 1.3-2.2, in male 1.2-2, times as wide as high; mesoscutum polished and punctate in both sexes; ovipositor sagittate, usually with tiny notch in dorsal angulation (figs. 82, 84) 20

16. Frons without a strong ridge behind antennal foramen; occipital carina weak or atrophied ventrally at point of normal junction with hypostomal carina; female with first segment of anterior tarsus asymmetrically expanded, lobate on outer side (fig. 78) 17

Frons with a distinct vertical ridge behind each antennal foramen; occipital carina strong, complete, joining hypostomal carina; female with first segment of anterior tarsus almost symmetrically expanded, not strongly elongated on outer side (fig. 79) 18

17. Anterior and posterior orbits narrowly yellowish or whitish, interrupted dorsally and ventrally; mesoscutum entirely black ..... *asymmetricus* n. sp.

Anterior and posterior orbits broadly reddish-ferruginous, completely encircling eye; lateral lobes of mesoscutum reddish-ferruginous ..... *mirabilis* n. sp.

18. Coxae and trochanters reddish ..... *bilobatus* n. sp.

Coxae and trochanters blackish or black and white 19

19. Hind femur reddish-ferruginous ..... *symmetricus* n. sp.

Hind femur blackish ..... *leucopus* Ashmead

20. Areolet with intercubiti subparallel (figs. 39-40); flagellum 40-55-segmented; large species 10-25 mm. long 21

Areolet with intercubiti convergent (figs. 41, 42); flagellum 30-40-segmented; smaller species 4-11 mm. long 30

21. Head and thorax largely ferruginous; male with thorax more or less black on a ferruginous background 22

Head and thorax black or black and white 23

22. Occipital carina joining hypostomal carina about basal width of mandible from mandible; sheaths of ovipositor as long as tergites 2-5; ovipositor with fine teeth on ventral margin ..... *pacificus* Cresson

Occipital carina joining hypostomal carina less than basal width of mandible from mandible; sheaths of ovipositor as long as abdomen; ovipositor with very coarse teeth on ventral margin (fig. 84) ..... *serraticaudus* n. sp.

23. Coxae and trochanters largely reddish-ferruginous 24

Coxae and trochanters black, or black and white 26

24. Frons without a strong ridge behind each antennal foramen, coarsely rugulose, often transversely so below; restricted to Pacific coastal region or central valley of California ..... *tejonensis* Cresson

Frons with a ridge behind each antennal foramen, finely rugulose or punctate above, smooth and polished below; occur in higher mountains from California to B.C., east to Arizona and Nevada 25

25. Flagellum 46-segmented; female ..... *rufopedibus* n. sp.

Flagellum 47-52-segmented; male ..... *pacificus* Cresson

26. Hind tibia reddish; hind femur in female with a distinct ventral ridge (fig. 49), in male usually with a trace of such ridge ..... *robustus* Cresson

Hind tibia, blackish, or fuscous with a ferruginous line; hind femur in both sexes without a ventral ridge 27

27. Gena moderately receding behind eye, in female much longer opposite ventral margin of eye than opposite dorsal margin; anterior tarsus in female very broadly expanded in most specimens; male with tegula usually black 28

Gena strongly receding behind eye, in female about as long opposite ventral margin as opposite dorsal margin of eye; anterior tarsus in female slightly, if at all, expanded; male often with tegula white or white-spotted 29

28. Pubescence brown or black; hind femur black ..... *dirus* Cresson

Pubescence silvery-white; hind femur usually reddish ..... *relativus* Cresson

29. Hind femur reddish ..... *mimicus* n. sp.
Hind femur blackish ..... *temporalis* n. sp.
30. Legs entirely black 31
At least hind femur reddish, often much more of legs reddish 32
31. Gena in lateral view long, flat, and only slightly receding behind eye; propodeum with apical transverse carina strong and complete; speculum as strongly punctate as rest of mesopleurum ..... *latigenalis* n. sp.
Gena in lateral view short, convex and strongly receding behind eye; propodeum with apical transverse carina weak, especially in middle; speculum smoother and more finely punctate than rest of mesopleurum ..... *inornatus* n. sp.
32. First tergite in female with dorsal carinae very prominent, area between carinae somewhat longitudinally grooved; male with genitalia as in fig. 67 ..... *dorsicarinatus* n. sp.
First tergite in female with dorsal carinae weak or entirely absent; male unknown 33
33. Mesopleurum irregularly rugulose-striate; female with hind femur 4 times as long as high; first flagellar segment 4.5 times as long as wide ..... *rugulosus* n. sp.
Mesopleurum closely, granularly punctate; female with hind femur 5-7 times as long as high, first flagellar segment 5-6.5 times as long as wide 34
34. Propodeal spiracle 3 times as long as wide; sheaths of ovipositor as long as abdomen; ovipositor recurved; 10 mm. long ..... *recurvatus* n. sp.
Propodeal spiracle twice as long as wide; sheaths of ovipositor as long as tergites 2-4 or 2-5; ovipositor straight; length 4-7 mm. 35
35. Legs including coxae and trochanters reddish ..... *ocellaris* n. sp.
Coxae and trochanters blackish ..... *aridus* n. sp.
36. Head, thorax, and abdomen largely ferruginous; flagellum 25-28 segmented ..... *minimus* n. sp.
Head and thorax black or black and white; abdomen black, reddish, or black and reddish; flagellum 29-45-segmented 37
37. Abdomen black ..... *viduatorius* Fabricius
Abdomen reddish, or reddish and black 38
38. Hind coxae and trochanters largely reddish, sometimes stained with fuscous near base ..... *rufovinctus* n. sp.
Hind coxae and trochanters black 39
39. Hind femur black ..... *albitarsis* (Cresson) 40
Hind femur reddish 41
40. Male scutellum white or white-spotted; female with wings hyaline or dilutely infumate (Eastern subspecies) ..... *albitarsis albitarsis* (Cresson)
Male scutellum black; female with wings dilutely infumate to deep fuscous (Western subspecies) ..... *albitarsis coloradensis* Ashmead
41. Occiput shallowly concave; female with sheaths of ovipositor very short, as long as tergites 2-4 ..... *curticaudus* n. sp.
Occiput deeply concave; female with sheaths of ovipositor longer than tergites 2-4 42
42. Areolet with intercubiti contiguous on anterior side (fig. 43) ..... *areolatus* n. sp.
Areolet with intercubit separate on anterior side; (fig. 31) 43
43. Flagellum 29-36-segmented; anterior tibia in female stout, strongly and convexly swollen from basal fourth to tip (fig. 47); hind tibia ferruginous at least at base, tip often darker 44
Flagellum 34-45 segmented; anterior tibia in female more slender, increasing gradually in diameter from basal fourth to tip (fig. 48); hind tibia often uniformly piceous to dull black 45
44. Female with sheath of ovipositor not quite so long as abdomen; male with face black with yellowish-white spots on orbits and often on face and clypeus ..... *persimilis* Cresson
Female with sheath of ovipositor as long as, or longer than, abdomen; face in male entirely yellowish-white; (restricted to area from S. Dak. and Man. west to Oregon and B.C.) ..... *associatus* n. sp.
45. Sheath of ovipositor shorter than, to as long as, abdomen beyond first tergite; male with middle segments of hind tarsus white ..... *mutatus* n. sp.

Sheath of ovipositor as long as, or longer than, abdomen; male with hind tarsus unicolorous 46

46. First tergite strongly angulate; first flagellar segment in female 6 times as long as wide ..... *atritibialis* n. sp.

First tergite not strongly angulate; first flagellar segment in female 7-8 times as long as wide ..... *ruralis* n. sp.

CRYPTUS ARCTICUS Schiodte

Fig. 74

Cryptus arcticus Schiodte, 1859, Berlin Ent. Zeit., **3**:144, female, male.—McLachlan, 1877, Journ. Linn. Soc. Zool., **14**:107, female.—Aurivillius, 1890, Bih. Svensk. Vet-Akad. Handl. **15**, pt. 4: 31, n. 14, T. 3 Fig. 10.—Roman, 1916, Ark. Zoologi, **10**, no. 22: 2.—Roman, 1933, Skifter om Svalbard ag Ishavet, No. 53: 7, male and female.—Roman, 1934, Ann. Mag. Nat. Hist., **14**, (Ser. 10), No. 84: 607, female.

Cryptus sponsor Gerstaecker, 2. Deutsch. Nordpohlfahrt, II, **1**:404, female.

Female.—Length 7-13 mm. ovipositor 2-3 mm.

Head with dense, erect, brownish-black pubescence; genae sub-polished, punctate and obliquely aciculate, slightly convexly narrowed behind eyes; postocellar line subequal to ocell-ocular line, ocell-ocular line twice as long as diameter of lateral ocellus; occiput deeply concave; vertex coriaceous anteriorly, punctate and polished behind ocellar triangle; frons deeply concave, coriaceous above, polished and smooth behind antennal foramina; eyes very small, almost as long dorso-ventrally as interocular line; face twice as wide as high, with a slight, median elevation; clypeus convex, punctate, with a highly polished, slightly reflexed margin, truncate at apex; malar space shagreened, 2-2.5 times as long as basal width of mandible (fig. 74); mandible 1.5 times as long as basal width, teeth subequal; occipital carina joining hypostomal carina 1.5 times basal width of mandible from mandible, sometimes atrophied ventrally; antenna long and slender, flagellum 40-segmented; first flagellar segment 7 times as long as wide, second 5.5 times as long as wide, following segments successively shorter and narrower.

Thorax with short, erect brownish-black pubescence; pronotum with no trace of epomia, finely granularly rugulose; mesoscutum densely punctate, confluently so in front of scutellar fovea; scutellar fovea longitudinally striate; scutellum punctate, sloping gradually to apex; prepectoral carina weak and extending about half way to subalar tubercle; sternaulus complete, strongly impressed at base, weaker posteriorly; mesopleura, metapleura, and propodeum granularly rugulose; propodeum with both basal and apical transverse carinae strong, petiolar area a little more than twice as long as distance from apical carina to base of propodeum; propodeal spiracle oval, 1.5 times as long as broad.

Legs long and slender, coxae granularly punctate, densely clothed with erect black pubescence; hind femur 5 times as long as high, hind tibia 1.2 times longer than hind femur, longer spur of hind tibia 0.5 as long as first segment of hind tarsus; anterior tarsus simple; claw small, with fine pectination at base.

Areolet small, convergent, first intercubitus reclivous, second intercubitus

inclivous, anterior side of areolet shorter than either intercubitus; second recurrent vein simply arched; ramellus distinct, curved; nervulus antefurcal.

Abdomen finely coriaceous, except petiole which is depressed and polished; petiole and postpetiole laterally with erect, black pubescence; petiole with dorsal carinae moderately elevated, ending opposite spiracles, postpetiole 3 times as wide as petiole; second tergite 1.5 times as wide on posterior margin as long, 1.3 times longer than third tergite; third tergite twice as wide as long; following tergites successively shorter; ovipositor sagittate, sheath of ovipositor as long as tergites 2-5.

Black; legs beyond trochanters, and abdomen, except base of first tergite, reddish-ferruginous; wings hyaline, suffused with fuscous; dot opposite top of eye and narrow lines on posterior orbits yellowish-white.

Male.—Unknown to present writer. According to the original Latin description, the male differs in the usual secondary sexual characters, such as more slender, cylindrical flagellum, more slender abdomen, etc. The malar space may be somewhat shorter than in the female.

Types.—Male and female from Greenland, presumably in the Zoological Museum, Copenhagen, Denmark, with the rest of the Schiodte collection.

Distribution.—ALASKA: three females, Mt. McKinley, North Peak, F. W. Morgand; 1 female Mt. Whitney, July 31, 1915. BRITISH COLUMBIA: 1 female, Rogers Pass, August 1, 1908, 4500 feet, J. C. Bradley. COLORADO. GREENLAND: Type locality. Roman (1933:7) records it from Vegasund, ϕya, Holmbukta in King Oscars Fjord, and Dusenforden. LABRADOR, 1 female, Rama, 1898, A. Stecker-J. D. Sornborger. Specimens in USNM, MU, CU, AES, MCZ.

Remarks.—This species is apparently moderately common in Greenland, the type locality, but it has never before been recorded from other localities. Roman (1933:7) thought that the species was of American origin and the records above seem to confirm his belief. The species is apparently confined to the boreal life zone, and the Colorado specimen was probably collected on some high mountain top. The long malar space, diagonally aciculate genae, erect black pubescence, and short propodeal spiracle make this one of the most distinct species of *Cryptus*.

Cryptus genatus, new species

Figs. 32, 50, 81

Female.—Length 11 mm., ovipositor 4 mm.

Head very densely punctate with long, erect, black pubescence; genae punctate-aciculate, in some lights giving the effect of oblique, irregular striations, slightly convexly narrowed behind eyes; ocell-ocular line 1.2 times as long as post-ocellar line, 1.6 times longer than diameter of lateral ocellus; occiput deeply concave; vertex strongly, granularly punctate; frons shallowly excavated, irregularly ugulose, without ridges behind antennal foramina; eyes with inner margins parallel, slightly sinuate above antennal foramina; face 2.5 times as wide as high, with a slight, median elevation; clypeus strongly convex and abruptly depressed beyond middle, with a thin, highly polished, slightly reflexed margin; malar space subequal to basal of mandible, shagreened; mandible about 1.6 times as long as basal width, teeth, subequal; antenna 0.7 as

long as body, flagellum 41-segmented, first segment 6 times as long as wide, second segment 0.8 as long as first, third slightly shorter than second, following segments successively shorter; occipital carina atrophied ventrally, not joining hypostomal carina.

Thorax stout, with short, dense, dark pubescence; pronotum rugulose-punctate, epomia present; mesoscutum subpolished, punctate, confluently so in front of scutellar fovea; notaulices strong, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum including lateral areas coarsely punctate, sloping gradually to apex; prepectoral carina weak, extending about 0.7 distince to subalar tubercle; sternaulus complete, but not deeply impressed; mesopleura including speculum, metapleura, and propodeum strongly reticulately punctate; propodeum with trace of basal transverse carina medially apical, transverse carina strongly laterally, weaker medially, posterior face of propodeum nearly vertical, about as long as dorsal face; propodeal spiracle 2.5 times as long as wide.

Legs moderately stout, coxae subpolished, densely punctate, and, like rest of legs, with dense, black pubescence; hind femur 6 times as long as high; hind tibia somewhat flattened, 1.2 times as long as hind femur, longer spur 0.4 as long as first segment of hind tarsus; claw (fig. 32) pectinate at base, with a large terminal tooth in pecten, stout bristles as base of claw.

Areolet slightly convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side about as long as second intercubitus; second recurrent vein simply arched, received beyond middle of areolet; ramellus long, slightly curved.

Abdomen (fig. 81) stout, somewhat depressed, coriaceous; petiole depressed, coarsely granulate laterally, with erect black pubescence, postpetiole 3 times as broad as petiole, dorsal carinae weakly indicated; second tergite shorter than petiole, posterior margin 1.3 times as broad as base, nearly 1.5 times as broad at posterior margin as long; third tergite shorter than second, twice as broad as long; following tergites successively shorter and narrower, but transverse; ovipositor decurved apically, entirely without dorsal angulation and notch in angulation; sheaths of ovipositor as long as tergites 2-6.

Black, the head entirely without orbital markings, the abdomen with a shimmering blue-black reflection in certain lights; hind femur reddish-ferruginous; tips of fore and middle femora, fore and middle tibiae beneath and more or less of tarsi piceous; first segment of hind tarsus black, segments 2-4 flavous, segment 5 piceous.

Allotype.—Male, differs from female in more cylindrical flagellar segments, slightly coarser sculpture, malar space 0.8 as long as basal width of mandible, segments 2-4 of hind tarsus being more definitely yellowish-white, and in possessing very narrow, yellowish-white posterior orbits. Subgenital plate and genitalia (Plate 4, fig. 50). The broadly triangular base of the digitus appears to be of some specific value.

Holotype.—Female, South Creek, Beaver Co., Utah, Cat. No. 55425, U. S. National Museum, Washington, D. C.

Allotype.—Male, Beaver Valley, Utah, in U. S. National Museum, Washington, D. C.

Paratypes.—ALBERTA: Lethbridge, Waterton, Waterton Lakes. BRITISH COLUMBIA: Fernie. CALIFORNIA: Barstow. COLORADO: Camp Creek R. Station, Durango, Electra Lake, Morrison, Westcliff. MONTANA: Bozeman. NEVADA (State record only). NEW MEXICO: Aspen Ranch, Santa Fe Co., ex *Malacosoma fragilis*. OREGON: Buck's Creek. SASKATCHEWAN: Lake Katepwe, ex *Malacosoma disstria*. Specimens in USNM, CN, MU, TOW, AES, CU, AMNH, MONT. Specimens collected from May until September.

Remarks.—Closely allied to the European *C. cyanator* Gravenhorst in coarse sculpture, propodeal and ovipositor characters. Both have the same black color with shimmering blue reflection, and black pubescence. *Cyanator* has *all* the legs below trochanters largely reddish, whereas *geneatus* has only *hind* femora reddish. Allied to the *asymmetricus* group in having occipital carina atrophied ventrally at point of normal junction with hypostomal carina and in the decurved ovipositor without dorsal angulation. Two specimens of *luctuosus* Cresson from Mt. Rainier, Wash., are black with only the hind femora reddish, but are easily distinguished from *genatus* on sculptural characters. The strength of the hypostomal carina and propodeal carina is subject to much variation. Length 8-14 mm.

Cryptus rugosiscutum, new species

Female.—Length 10 mm., ovipositor 4 mm.

Head with short, whitish pubescence; gena in lateral view much shorter than eye, minutely and densely punctate, strongly narrowed behind eye, nearly flat; ocell-ocular line 0.9 as long as an ocellus, post-ocellar line 1.3 times as long as ocell-ocular line; occiput deeply concave; vertex coriaceous, ocellar triangle punctate; frons shallowly excavated, irregularly rugulose dorsally, transversely rugulose ventrally, entirely without a ridge behind each antennal foramen; face 1.8 times as wide as high, with a prominent median elevation, as coriaceous as malar space; clypeus elevated at base, distinctly depressed beyond middle, margin slightly reflexed and polished, arcuately truncate; labrum trapezoidal; malar space equal to basal width of mandible; mandible 1.5 times as long as basal width; occipital carina complete, joining hypostomal carina 0.8 basal width of mandible from mandible; antenna as long as body, flagellum 42-segmented, basal segment 7 times as long as wide, second shorter, third 0.7 as long as first, following segments successively shorter and narrower.

Pronotum irregularly rugulose throughout, with prominent epomia; mesoscutum dull, irregularly rugulose along notaulices and lateral margins of mesoscutum, anterior and lateral lobes of mesoscutum with central portion coriaceous; notaulices foveolate anteriorly, almost obliterated centrally by confluent sculpture of mesoscutum, but extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum convex, moderately punctate, subpolished; prepectoral carina extending 0.7 distance to subalar tubercle; sternaulus deeply impressed, broad, complete; mesopleura, metapleura, and propodeum with basal transverse carina weak, but present; apical transverse carina strong, produced into a short apophysis on either side; propodeal spiracle 3 times as long as wide.

Legs long and slender, hind coxae densely, granularly punctate, subpolished, with short, appressed whitish pubescence; hind femur about 6 times as long

as high; hind tibia 1.2 times as long as hind femur, longer hind tibial spur 0.3 as long as first segment of hind tarsus; claw small, not so long as third tarsal segment, simply pectinate at base; anterior tarsus simple.

Areolet moderately convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side as long as second abscissa of cubitus; second recurrent vein gently arched, received beyond middle of areolet; ramellus present.

Abdomen stout, finely coriaceous; petiole depressed without transverse rugosities laterally; postpetiole 3 times as wide as petiole, dorsal carinae weak, fading out opposite spiracles; second tergite 0.8 as long as wide at posterior margin, posterior margin 1.75 times as long as base; third tergite 1.5 times as wide as long; following tergites transverse, successively shorter and narrower; ovipositor sagittate; sheaths of ovipositor about as long as tergites 2-6.

Head and thorax black; scape beneath, clypeus, spot on mandible, abdomen, and legs, reddish-ferruginous; incomplete dorsal annulus centering on flagellar segments 4 and 5, subalar tubercle, orbits entirely encircling eyes except at top of eye, yellowish-white; tegulae ferruginous, whitish on anterior half; wings hyaline, tinged with yellowish, veins and stigma dark piceous.

Holotype.—Female, Carmel, California, February 19, 1928, L. S. Slevin. No. 5207 California Academy of Sciences, San Francisco, California.

Paratypes.—CALIFORNIA: Berkeley, September 29, 1934, Bohart; Carmel, February 26, 1928, April 8, 1928, April 25, 1926, October 24, 1922, October 1925, L. S. Slevin; Central California, June 23, 1908, F. X. Williams; Mill Valley, Marin Co., April 13, 1926, M. C. Van Duzee. Specimens in CAS, MU, UCLA.

Remarks.—The rugulose mesoscutum and incomplete annulus centering on flagellar segments 4-5 immediately distinguish this species and *crassisculptus* from all other North American *Cryptus*. *Crassisculptus* is found in New Mexico and Arizona and has black coxae and trochanters, while *rugosiscutum* occurs in California and has entirely reddish legs. *Rugosiscutum* is 9-14 mm. long. There is some variation in the size of white markings on orbits, pronotum, and flagellar annulus. One paratype has base of scutellum reddish. The first flagellar segment varies from 7-8 times as long as wide.

Cryptus crassisculptus, new species

Fig. 51

Female.—Length 12 mm., ovipositor 4 mm.

Differs from preceding description of *rugosiscutum* as follows: basal flagellar segment 8 times as long as wide, sheaths of ovipositor as long as tergites 2-4, coxae and trochanters black.

Black; abdomen entirely and legs beyond trochanters reddish-ferruginous, tibiae and tarsi somewhat infuscated; incomplete dorsal annulus centering on flagellar segments 4 and 5, narrow lines on anterior and posterior orbits and line opposite top of eye, anterior margin of tegula, yellowish-white; wings hyaline, stigma and veins black.

Male.—Differs from female in having finer sculpture, rugulosity of mesoscutum less pronounced and confined largely to areas along notaulices and

lateral margins of mesoscutum, anterior and lateral lobes of mesoscutum with central areas polished with large punctures; pubescence of head longer than in female; propodeum with both basal and apical transverse carinae present, but apophyses of apical carina not so strongly developed as in female; abdomen more slender, first segment with sternite extending posteriorly beyond a line tangential to spiracle; subgenital plate and male genitalia (fig. 51).

Black; abdomen and all femora reddish-ferruginous; hind tibia and basal half of first segment of hind tarsus infuscated; scape beneath, V-shaped mark on face, anterior and posterior orbits, clypeus, spot on mandible, lines on anterior sides of anterior and middle tibiae and first segment of anterior and middle tarsi (rest of anterior and middle tibiae and tarsi ferruginous), tegula and subalar tubercle, white; distal half of first segment, segments 2-4 and basal half of fifth segment of hind tarsus brown.

Holotype.—Female, Huachuca, Arizona, May 23, 1937, W. Benedict, University of Kansas, Lawrence, Kansas.

Allotype.—Male, Jemez Springs, New Mexico, April 28, 1913, John Woodgate, Cornell University, Ithaca, N. Y.

Paratype.—1 female, Las Vegas, New Mexico, 1898 (FC).

Cryptus flagellatus, new species

Female.—Length 11 mm., ovipositor 6 mm.

Head densely clothed with short, whitish pubescence; gena in lateral view much shorter than eye, minutely and densely punctate, strongly narrowed behind eye, nearly flat; ocell-ocular line as long as an ocellus, post-ocellar line 1.5 times as long as ocellus; occiput deeply concave; vertex coriaceous, ocellar triangle punctate; frons shallowly excavated, irregularly rugulose dorsally, transversely rugulose ventrally, entirely without a ridge behind each antennal foramen; face 1.7 times as wide as high, with a median elevation, as coriaceous as malar space; clypeus moderately convex, margin slightly reflexed and polished, truncate; labrum trapezoidal; malar space 0.8 as long as basal width of mandible; mandible 1.5 times as long as basal width of mandible; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 42-segmented, first segment 8 times as long as wide, second 0.7 and third 0.5 as long as first; following segments successively narrower and shorter.

Pronotum irregularly rugulose throughout, with prominent epomia; mesoscutum dull, irregularly rugulose along notaulices and lateral margins of mesoscutum with central portions of anterior and lateral lobes of mesoscutum coriaceous; notaulices foveolate anteriorly, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea irregularly punctate; scutellum short and convex, polished, finely punctate; prepectoral carina extending 0.7 distance to subalar tubercle; sternaulus deeply impressed, broad, complete; mesopleura, metapleura, and propodeum irregularly, rugulose-punctate; speculum elevated, smooth and shining, propodeum with basal transverse carina weak, but present; apical transverse carina strong, laterally produced

into a short apophysis on either side, traces of median longitudinal carinae between basal and apical transverse carinae; propodeal spiracle 2.5 times as long as wide.

Legs long and slender, hind coxae densely granularly punctate, subpolished, with short, appressed whitish pubescence; hind femur about 6 times as long as high, hind tibia 1.3 times as long as hind femus, longer hind tibial spur 0.3 as long as first segment of hind tarsus; claw small, not as long as third tarsal segment, simply pectinate at base; tarsi and tibiae normal, not expanded.

Areolet moderately convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side 0.6 as long as second intercubitus, second recurrent vein simply arched, received about in middle of areolet, ramellus present.

Abdomen finely coriaceous, first tergite without dorsal carinae or transverse rugosities laterally, postpetiole 3 times as wide as petiole; second tergite twice as long as basal width, as long as posterior margin; third tergite 1.1 times as wide as long, following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-6.

Black: abdomen beyond first tergite reddish-ferruginous; all femora, tibiae, and tarsi piceous, femora darkest, tarsi palest; narrow lines on anterior and posterior orbits and dot opposite top of eye, yellowish-white; wings hyaline tinged with yellowish, veins and stigma dark piceous.

Holotype.—Female, Colorado, in Academy of Natural Sciences, Philadelphia, Pa.

Paratypes.—1 female, Magdalena Mts., New Mexico, August, 1894 (MU); 1 female, Magdalena, New Mexico (KU); 1 female, Chiracahua Mt., Rustler's Pk., July 5, 1940, E. E. Kenaga (KU).

Remarks.—This species is easily placed in the *rugosiscutum* group because of its rugulose mesoscutum. In this group it is very distinct in its entirely blackish femora and flagellum. Paratypes show some variation in width of frons and abdominal tergites, and in the length of malar space and ocell-ocular lines; first flagellar segment varies from 7.5 to 9 times as long as wide; tegulae may have anterior half more or less white; first segment of abdomen may be more or less red and apical tergites somewhat piceous. Length 11-16 mm.

CRYPTUS LUCTUOSUS Cresson

Cryptus luctuosus Cresson, 1864, Proc. Ent. Soc. Phil., **3**:290, no. 3, female.—Cresson, 1865, Proc. Ent. Soc. Phil., **4**:265, no. 3, female.—?Provancher, 1886, Add. Faun. Ent. Can. Hym.: no. 5, male.—Gibson, 47th Ann. Rept. Ent. Soc. Ont.: 159.

Agrothereutes (Itamoplex) ebenus Viereck, 1916, Hym. Conn., Conn. N. H. Surv. Bull. **22**:331, 333. New synonymy.

Cryptus caligatus Cushman, 1927, Proc. U. S. Nat. Mus., **72**, art. 13 (No. 2709): 2-3, female. New synonymy.

Female.—Length 9 mm., ovipositor 2 mm.

Head very minutely coriaceous, densely clothed with short, silvery-white pubescence; genae subpolished, sparsely punctate, about as long as eyes in lateral view, slightly convexly narrowed behind eyes; postocellar line subequal

to ocell-ocular line, 1.5 times as long as diameter of an ocellus; occiput shallowly concave; eyes slightly, arcuately emarginate above antennal foramina; frons shallowly excavated, rugulose on lower half, coriaceous near ocelli; face about twice as wide as high, with a very slight median elevation; clypeus abruptly inflexed apically, subnasutiform, with a narrow, slightly reflexed, polished margin; malar space slightly longer than basal width of mandible, shagreened; mandible about 1.5 times as long as basal width; antenna short and stout, broken in type but 30-40 segmented in many specimens, first flagellar segment 4 times as long as wide, following segments successively short, first as long as fourth and fifth together.

Thorax dorsally and ventrally polished and densely punctate, laterally rugoso-punctate; pronotum punctate, along dorsal margin, irregularly rugulose below, epomia short; mesoscutum shining, finely and densely punctate, notaulices strong, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum slightly convex, polished, very minutely and sparsely punctate; prepectoral carina weak dorsally but attaining subalar tubercle; sternaulices complete, weaker posteriorly; mesopleura, metapleura, and propodeum finely, reticulate-rugulose; propodeum with basal transverse carina indicated, apical transverse carina strong, especially laterally; propodeal spiracle broadly oval, not quite 1.5 times as long as wide.

Legs moderately slender, all coxae very finely coriaceous and densely punctate, covered with short, somewhat silvery pubescence; hind femur 4.5 times as long as high; hind tibia 1.2 times as long as hind femur, longer spur of hind tibia 0.4 times as long as first segment of hind tarsus; anterior tarsus simple, claw small, weakly pectinate at base, without large terminal tooth in pecten.

Areolet moderately convergent anteriorly, its anterior side as long as first abscissa of cubitus; second recurrent vein simply arched, received beyond middle of areolet; ramellus very short; nervulus interstitial to antefurcal.

Abdomen robust, finely coriaceous except petiole which is polished dorsally and transversely rugose laterally; petiole depressed, first tergite less than twice as long as width of postpetiole, dorsal carina indicated but not strong; second tergite 1.3 times as wide as long, 1.4 times as long as third tergite; following tergites transverse, successively shorter; ovipositor compressed, sagittate; sheaths of ovipositor not quite as long as tergites 2-4.

Black; short lines on posterior orbits, facial orbits opposite antennae, and a dot opposite top of eye, yellowish-white; legs black, all femora entirely and front and middle tibia more or less ferruginous, anterior tarsi ferruginous; wings uniformly fuliginous with a bluish gloss, stigma and veins black.

Lectotype.—Female, Rocky Mts., Colorado, No. 1144, Academy of Natural Sciences, Philadelphia, Pa.

The type of *ebenus* is No. 4883, Academy of Natural Sciences, Philadelphia, Pa., and the type of *caligatus* is No. 40433, U. S. National Museum, Washington, D. C.

Distribution.—ALBERTA: type and paratype of *caligatus* from Calgary; Banff. BRITISH COLUMBIA: Royal Oak; Victoria. CALIFORNIA: Napa Co.; San Francisco.

IDAHO: Collins; Moscow Mts. MASSACHUSETTS: type of *ebenus*: one other specimen from "Mass." NEW BRUNSWICK: St. Stephen, ex cocoons of *?Zaraea inflata* (Norton). NEW HAMPSHIRE: Mt. Washington. NEW YORK: Bemis Point; Ithaca. ONTARIO: Ottawa. OREGON: Lucky Boy Camp, Blue River. WASHINGTON: Coupeville; Mt. Ranier; Pullman, reared from *Trichiosoma taylori;* Wawawai. Specimens in USNM, CN, AES, TOW, MU, collected in the field from June until September.

Remarks.—The short, oval spiracle, entirely reddish hind femur, and black color should immediately distinguish this species from all other North American *Cryptus*. The amount of black on the leg varies, fore and middle femora, and anterior tibiae and tarsi varying from reddish-ferruginous to black. The strength of the propodeal carinae is also variable and not of sufficient value and constancy to separate *caligatus* from *luctuosus*. The flagellar segments vary from 30-40 and the size from 9-13 mm. in the female. The male described by Provancher in 1886 is now represented only by a pin and label in the collection at Quebec and the specimen very probably was not a *Cryptus* (s. str.) but a species of *Chaeretymma* Foerster. In many specimens there is an irregular ridge extending anteriorly across the metapleurum from the hind coxal cavity. No male of *luctuosus* was seen during this study.

CRYPTUS IROQUOIS (Viereck)

Agrothereutes (Itamoplex) iroquois Viereck, Hym. Conn., Conn. N. H. Surv. Bull., **22**:331 and 333.

Female.—Length 8 mm.; ovipositor 3 mm.

Head coriaceous, finely and densely punctate with short, somewhat appressed silvery-white pubescence; genae strongly obliquely narrowed behind eyes, slightly convex; post-ocellar line 1.5 times longer than ocell-ocular line, ocell-ocular line subequal to diameter of lateral ocellus; occiput deeply concave; vertex granularly punctate; frons shallowly excavated, rugulose dorsally but polished and entirely without ridges behind antennal foramina; eyes subparallel, very slightly sinuate within; face 1.8 times as wide as high, with a median elevation; clypeus strongly convex, apically depressed, with a highly polished, slightly reflexed apical margin; labrum projecting; malar space slightly longer than basal width of mandible, shagreened; mandible 1.5 times as long as basal width; antenna 0.7 as long as body, flagellum 33-segmented, basal segment 5 times as long as wide, second 0.8 as long as first, third and fourth segments together slightly longer than first.

Pronotum punctate dorsally, rugulose ventrally, epomia weak; mesoscutum finely and densely punctate; notaulices impressed, but not strong, extending posteriorly to a line drawn tangent to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum about as densely punctate as lateral lobes of mesoscutum; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus deeply impressed at base, complete, subfoveolate; mesopleura, metapleura, and propodeum densely punctate; speculum polished, feebly and minutely punctate; propodeum with apical transverse carina only, strong laterally, weak medially; propodeal spiracle short, oval, 1.5 times as long as wide.

Legs moderately long and slender; coxae densely confluently punctate, with

short, somewhat appressed, silvery-white pubescence; hind femur 5 times as long as high, hind tibia 1.2 times as long as hind femur; longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tarsi simple, claw small, finely pectinate at base.

Areolet convergent anteriorly, first intercubitus reclivous, second intercubitus inclivous, anterior side as long as second abscissa of cubitus; second recurrent vein simply arched, received at apical third of areolet.

Abdomen very finely coriaceous, subpolished; petiole flattened dorsally and ventrally, laterally weakly transversely rugose; postpetiole 2.5 times as wide as petiole, first tergite 3 times as long as wide at postpetiole; second tergite with base 0.6 as wide as length of tergite; following tergites transverse, successively shorter and narrow; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-4.

Black; anterior and middle legs beyond trochanters and hind femur, except black tip, ferruginous; narrow lines on posterior orbits, anterior orbits opposite frons, and segments 2-4 of hind targus more or less, whitish; wings hyaline, tinged with fuscous; veins and stigma piceous; basal three or four segment of flagellum rufo-piceous to piceous, following segments successively more fuscous; abdomen black with apices of second, third, and fourth tergites narrowly piceous.

Male.—Differs frm previous account of female in having flagellar segments cylindrical, sculpture slightly coarser, propodeum with posterior transverse carina weaker and basal transverse carina indicated; petiole of abdomen more slender, postpetiole only slightly wider than petiole; male subgenital plate and genitalia (fig. 52).

Black, with the following parts whitish: posterior orbits, dot opposite top of eye, anterior orbits, clypeus, except margin, labrum, spot on mandible, palpi, tegulae, subalar tubercle, spot on anterior coxa and trochanter, most of scutellum, all middle tarsus except last segment, all of hind tarsus except base of first segment and apex of last segment; all femora, except black apex of hind femora, fore and middle tibiae and anterior tarsus pale to dark ferruginous; a piceous line on posterior margins of second and third tergites.

Holotype.—Female, New York, No. 4882, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Chestnut Hill, Pa., August 10, 1932, G. B. Sleesmau. In U. S. National Museum, Washington, D. C.

Distribution.—ILLINOIS: Algonquin. MASSACHUSETTS: Amherst; Salem; MINNESOTA: John Latsch State Park. NEW YORK: Armonk; Bemis Point; Homer; Ithaca; Ringwood; Rome; West Farms, New York City; ONTARIO: Orville. PENNSYLVANIA: Pennypack Peak, Philadelphia. QUEBEC: Montreal. Specimens in USNM, ILL, MSC, MU, CU, TOW, CN. Collected in the field from May through July.

Remarks.—Varies in size from 6-10 mm.; the flagellum is 30-33 segmented, and the white markings are somewhat variable in size. The postscutellum is sometimes white. *C. iroquois* is easily separated from most black species of *Cryptus* with reddish femora by the short, oval spiracle. The simply arched second recurrent vein will immediately distinguish it from the European *vidua-*

torius Fabricius, and the key characters will distinguish it from *luctuosus* Cresson. The species has been collected often in damp meadows or bogs while sweeping jewelweed (*Impatiens*) and various Umbelliferae.

CRYPTUS ALTONII Dalla Torre

Fig. 55

Cryptus proximus Cresson, 1864, Proc. Ent. Soc. Phil., **3**:290, no. 2, female. (not Fonscolombe 1850).—Cresson, 1865, Proc. Ent. Soc. Phil. **4**:265, no. 2, female.—Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 359.—Provancher, 1879, Nat. Can., **11**:131, No. 1, female.—Provancher, 1883, Pet. Faun. Ent. Can. Hym.: 329, 330, no. 1, female.—Provancher, 1886, Add. Faun. Ent. Can. Hym.: 61, female.—Bridwell, 1899, Trans. Kans. Acad. Sci., **16**: 204.—Fletcher and Gibson, 1908, 29th Ann. Rept. Ent. Soc. Ont.: 128.

Cryptus robustus (Cresson) Provancher, 1874, Nat. Can., **6**:177, 178, no. 2, female (not Cresson).—Provancher, 1875, Nat. Can., **7**:177, (not Cresson).—?Gibson, 1916 46th Ann. Rept. Ent. Soc. Ont.: 222.

Cryptus altonii Dalla Torre, 1902, Cat. Hym., **3**, pt. 2: 560 (new name for *proximus* Cresson, not Fonscolombe 1850).—Criddle, 1928, 58th Ann. Rept. Ent. Soc. Ont.: 102.—Cushman, 1928, Leonard's List Insects N. Y., Corn. Univ. Agr. Exp. Sta. Mem. 101: 931.—Knowlton and Harmston, 1939, Utah Acad. Sci. Arts & Lett., **16**:61.

Female.—13 mm.; ovipositor 6 mm.

Head very finely coriaceous, with short, silvery-white pubescence; gena subpolished, sparsely punctate, as long as eye in lateral view, slightly convexly narrowed behind eye; occiput deply concave; postocellar line subequal to ocellocular line, 1.6 times as long as diameter of lateral ocellus; frons deeply excavated with a strong, vertical ridge behind each antennal foramen, densely punctate; face twice as wide as high with a median elevation; clypeus convex with a highly polished, slightly reflexed margin; malar space shagreened, slightly longer than basal width, teeth subequal; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna broken in type, in other specimens 0.7 as long as body, flagellum about 49-segmented, first segment 7 times as long as wide, second 0.7 as long as first, third 0.6 as long as first, following segments successively shorter and narrower.

Pronotum with dorsal portion between epomia somewhat longitudinally rugulose, with epomiae distinct and curving anteriorly, lateral portion of pronotum punctate to rugulose; mesoscutum with notaulices strong, minutely foveolate, extending posteriorly as far as posterior margin of tegulae, median area of mesoscutum closely and confluently punctate, lateral areas with punctures separate; scutellar fovea deep, longitudinally striate; scutellum flat, subpolished, very minutely punctate; prepectoral carina extending about 0.7 distance to subalar tubercle; sternaulus complete, broad and deep, anteriorly subfoveolate; speculum elevated, polished, somewhat punctate; propodeum with apical carina present and complete, weakest in middle; a trace of basal carina in middle; propodeal spiracle 2.5 times as long as wide.

Legs long and moderately slender, coxae polished, rather densely punctate and covered with short, somewhat appressed, silvery-white pubescence; hind femur 5 times as long as wide; hind tibia 1.2 times as long as hind femur,

longer spur of hind tibia 0.4 as long as first segment of hind tarsus; tarsi simple; claws small, those of anterior tarsi not quite so long as median length of third segment; claw pectinate at base, with large terminal tooth in pecten.

Areolet large, first intercubitus reclivous, second intercubitus inclivous, anterior side about as long as first abscissa of cubitus; second recurrent vein simply arched, received beyond middle of areolet.

Abdomen finely coriaceous, except for petiole which is polished dorsally and more or less transversely rugulose laterally; petiole somewhat depressed basally, postpetiole with dorsal carinae fading out opposite spiracle, postpetiole 3 times as wide as petiole; second tergite 1.7 times as long as basal width; third tergite 1.5 times as wide as long; following tergites transverse, successively narrower and shorter; ovipositor sagittate, sheaths about as long as abdomen beyond petiole.

Black; legs beyond trochanters ferruginous, tarsi especially hind tarsi somewhat paler; short lines on posterior and anterior orbits opposite antenna, and a dot opposite top of eye, yellowish-white; wings dilutely, uniformly infumate, stigma and veins blackish.

Male.—Length 14 mm., antenna 10 mm.

Differs from previous description of female as follows: post-ocellar line 1.2 times as long as ocell-ocular line; ridge behind each antennal foramen very distinct; malar space 0.8 as long as basal width of mandible; flagellum 40-segmented; basal transverse carina complete, almost as strong as apical carina; apical transverse carina completely demarking petiolar area with two longitudinal carinae extending from petiolar foramen to apophyses; abdomen more slender and polished; petiole with sternite extending posteriorly to a line opposite spiracles, postpetiole twice as wide as petiole; abdomen somewhat compressed beyond second tergite; subgenital plate angularly produced on posterior margin; paramere large, flattened with a strong angulation and tooth-like pad on apical margin and a lobe internally on inner margin (see fig. 55).

Black; legs beyond first trochanters ferruginous; the following parts yellowish-white: dot opposite top of eye, posterior orbits, anterior orbits widening ventrally, clypeus except middle of apical margin, mandible medially, palpi, spots on fore and middle coxae and trochanters, tegulae, short line before tegula, subalar tubercle, and segments 2-4 of hind tarsi.

Lectotype.—Female, Colorado, No. 1150, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Seattle, Washington, July 24, 1931, Donald Denning, in collection of University of Minnesota, St. Paul, Minn.

Distribution.—*Altonii* is wide spread across northern United States and Canada. Specimens have been examined from Cape Breton Island, Nova Scotia, Quebec, Ontario, Saskatchewan, Manitoba, Alberta, and British Columbia with the northernmost from Fort Selkirk and Skagway in Alaska, Fort Simpson and Fort Norman on the McKenzie River in Northwest Territory, and Rama, Labrador. In United States *altonii* is widespread in Colorado, Montana, Wyoming, Idaho, Washington, Oregon and Utah. Specimens of interest in demarking its range in United States were collected in the following localities: NEW YORK, Cranberry Lake, Keene Valley, Newcomb, New Russia; MICHIGAN: Isle Royale; MINNESOTA: Beltrami County, Duluth, Grand Marais, Itaska

Park, Laporte, St. Louis County; SOUTH DAKOTA: Custer, Whitewood, Black Hills; KANSAS: state record quoted from Bridewell (1899); NEW MEXICO: Beulah, Coldcroft, Jemez Springs, Top of Las Vegas Range, White Mts. at 6700 ft.; ARIZONA: Haith Springs; CALIFORNIA: Carrville, Trinity Co.; Davis Creek, Modoc Co.; Pyramid Peak, El Dorado Co., 8000 ft.; Gold Lake, Sierra Co.; Ingo Co., 9700 ft.; King's R. Cyn, Fresno Co.; Meadow Valley, Plumas Co., 9700 ft.; Sisson. In flight from early in May until late in October. Specimens have been reared by Knowlton and Harmston (1939: 61) from pupae of *Malacosoma disstria*. Specimens in USNM, CN, AES, MCZ, AMNH, MU, BC, C, TOW, KU, CU, UCLA, MONT, UTAH, OR, SD, WASH.

Remarks.—Altonii is closely allied to the European *laborator* Thunberg, a rather variable species which has been split into a number of species of doubtful validity (see Schmiedeknecht, 1931: 44). The European species is said to occur from Scandinavia to Siberia, while *altonii* occurs from Alaska to Labrador. On distributional data, general color pattern, and general sculpture and structure, the two species are very similar. There appear to be differences in the size of the membranous pad of the paramere, in the size of the internal, median lobe of the paramere, and in other genitalic structures. In view of these differences, and because the European workers have been unable to agree on the limits of *laborator*, it seems wisest to keep the two species separate at the present time.

C. altonii varies in size from 10-18 mm.; in the female the basal flagellar segment is 6.5-9 times as long as wide; the amount of pale color on the face, coxae, and tarsi (especially in the male) is subject to considerable variation. The subgenital plate may be more or less pointed than in fig. 55. In collections *altonii* is more often confused with *robustus*. However, the key characters and the remarks under *robustus* should aid in separating these two species.

CRYPTUS PERPLEXUS Cresson

Fig. 56

Cryptus proximus ?var. *perplexus* Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 359, female.

Female.—Differs from female of *altonii* D. T. chiefly in having coxae and trochanters, scape ventrally, and palpi entirely, reddish-ferruginous.

Male.—The male differs from the preceding description of the male of *altonii* in having the postocellar line equal to ocell-ocular line. The following parts are ferruginous: scape ventrally, mandible in middle, palpi, legs except for yellowish-white segments 2-4 of hind tarsus; subgenital plate and genitalia (fig. 56).

Lectotype.—Female, California, No. 1147, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Julietta, Idaho, June 5, 1930, J. M. Aldrich, in U. S. National Museum, Washington, D. C.

Distribution.—BRITISH COLUMBIA: Agassiz, Creston, Cultus Lake, Kaslo Keremeos, Oliver, Robson, Salmon Arm, Topino, Vernon; CALIFORNIA: Big Pine Cr., Inyo Co.; Davis Creek, Modoc Co.; Gold Lake, Sierra Co.; King's R. Cyn., Fresno Co.; Giant Forest, Sequoia National Park; Strawberry Valley, El Dorado Co.; Summit; Vina; IDAHO: Julietta, Lewiston, Sweetman, Troy, Viola; NEVADA: "Nevada," Fallen;

OREGON: Corvallis, Portland, Rickreall, Scappoose, St. Helens; WASHINGTON: Almota, Coupeville, Colville, Mt. Ranier, N. Yakima, Pullman, Seattle, Toppenish, Union Creek, Walla Walla, Wolf Fork, Yakima. Earliest collection date, April 26; latest, October 27, both in Corvallis, Oregon. Specimens in USNM, CN, MU, BC, CAS, CU, AES, AMNH, OR, W.

Remarks.—*Perplexus* varies in size from 8-15 mm.; the amount of white markings on the head and legs of the male is somewhat variable. The male subgenital plate may be more or less angular than in fig. 56.

Cryptus crassifemur, new species

Fig. 53

Female.—Length 8 mm., ovipositor 4 mm.

Head very finely coriaceous, subpolished with sparse silvery-white pubescence, very thick antero-posteriorly; genae slightly convexly narrowed behind eyes, in lateral view ventral portion much longer than dorsal portion, ventral portion as long as eye; postocellar line subequal to ocell-ocular line, 1.5 times as long as diameter of lateral ocellus; occiput shallowly concave; vertex shining, coriaceous; frons shallowly excavated, punctate near ocelli, irregularly transversely rugulose, without a vertical ridge behind each antennal foramen; face twice as wide as high, with a median elevation; clypeus moderately convex, with a highly polished, slightly reflexed, truncate margin; malar space subequal to basal width of mandible; mandible 1.5 times as long as basal width of mandible; occipital carina joining hypostomal carina about basal width of mandible from mandible; hypostomal carina flange-like; antenna stout, 0.7 as long as body, flagellum 37-segmented, basal flagellar segment 3 times as long as wide, second segment not quite as long as first, third shorter, fourth 0.5 as long as first.

Pronotum finely punctate dorsally along mesoscutal margin, irregularly rugulose below, with only a trace of epomia; mesoscutum subpolished, finely but densely punctate; notaulices weak, fading out opposite middle of tegulae; scutellar fovea longitudinally rugose; scutellum broadly triangular, subpolished, very finely punctate; prepectoral carina complete, attaining subalar tubercle; sternaulus incomplete or very weak posteriorly; mesopleura, metapleura, and propodeum punctate; speculum very slightly elevated, smooth and more polished than rest of mesopleurum; propodeum with apical transverse carina only, complete, strongest laterally; propodeal spiracle about 3 times as long as wide.

Areolet large, slightly convergent anteriorly, first intercubitus slightly reclivous, second intercubitus inclivous, anterior side subequal to second abscissa of cubitus; second recurrent vein simply arched, received about in middle of areolet; ramellus very short.

Legs subpolished, rather stout; hind femur 3.5 times as long as high; hind tibia 1.3 times as long as hind femur, longer spur of hind tibia 0.4 times as long as first segment of hind tarsus; tarsal segments normal; claw small, finely pectinate at base, without a large terminal tooth in pecten.

Abdomen finely coriaceous, polished; petiole somewhat depressed dorsoventrally laterally granularly punctate or rugulose, but never transversely so, postpetiole about 3 times as wide as petiole; second tergite 0.6 as wide on

basal as on posterior margin, 0.8 as long as wide at posterior margin; third tergite 0.6 as long as wide; ovipositor sagittate, sheaths as long as abdomen without first tergite.

Ferruginous; antenna gradually becoming more fuscous from base to tip; lower, lateral portion of pronotum, teeth of mandible, vntral portion of frons directly behind antennal foramina, suture separating propodeum and metapleura, and sheaths of ovipositor black.

Male.—Differs from previous description of female as follows: malar space 0.9 as long as basal width of mandible, antennal segments of same diameter throughout, hind femur 6 times as long as high, apical transverse carina on propodeum merely indicated; abdomen more slender, postpetiole slightly wider than petiole.

Head black with the following parts yellowish-ferruginous; broad orbital lines completely encircling eyes, clypeus, labrum, mandible except base and teeth; thorax and abdomen ferruginous, with the following parts black; broad, transverse band on pronotum, posterior side of lateral cervical plates, notaulices and all sutures of thorax, scutellar fovea, basal and posterior margins of propodeum, extreme bases of all coxae; subalar tubercle and all tarsi pale yellowish-ferruginous; scape yellowish-ferruginous, rest of antenna black.

Holotype.—Female, Corvallis, Oregon, June 10, 1931, also typewritten labels c-1 and 541, in U. S. National Museum, Washington, D. C.

Allotype.—Male, Corvallis, Oregon, June 1, 1931, also typewritten labels c-1 and 541, in U. S. National Museum, Washington, D. C.

Paratypes.—BRITISH COLUMBIA: Adams Lake, June 16, 1923, W. B. Anderson; Vernon, July 17, 1917, Evans. CALIFORNIA: Berkeley, June 23, 1909, C. L. Fox; Davis, April 23, 1936, R. Bohart; Santa Cruz Mts.; Stanford University, May 1922; Mt. Tamalpais, May 28, 1922, C. L. Fox. OREGON: Corvallis, June 11, 1925, E. P. Van Duzee; Corvallis, June 10, 1931; Corvallis, May 29, 1900; Corvallis, June 4, 1931, H. A. Scullen; Siskiyou Pass, Jackson, 4500 ft., July 15, 1930, H. A. Scullen. WASHINGTON: "W.T.," Almota, May 25, 1913, N. A. Yothers; Pullman, May and June; Wawawai; also four males without data from Washington State College.

Remarks.—This species is intermediate between the genera *Cryptus* Fab. and *Compsocryptus* Ashmead, but must be placed in *Cryptus* because of the notaulices and short, but distinct, ramellus. In *Cryptus* it is very distinct from all other ferruginous species because of its stout femora and antennae in the female, and in the male because of its apically produced subgenital plate. Size 6-11 mm. The pale markings in the male are subject to considerable variation.

Cryptus strigosus, new species

Fig. 54

Female.—Length 13 mm., ovipositor 6 mm.

Head with very short, silvery-white pubescence; genae very short, especially dorsally, subpolished, flat, very slightly narrowed behind eyes; ocell-ocular line subequal to diameter of lateral ocellus, postocellar line 1.2 times ocell-ocular line; occiput shallowly concave; vertex punctate; frons deeply excavated, irregulaly and somewhat transversely rugulose near antennal foramina, vertical

ridge behind each foramen merely indicated; face twice as wide as high, with a very gradual median elevation; clypeus gently convex with a thin, highly polished, slightly reflexed margin; mandible 1.5 times as long as basal width, teeth subequal; malar space subequal to basal width of mandible; occipital carina joining hypostomal carina a little more than basal width of mandible from mandible; hypostomal carina high, flange-like; antenna 0.7 as long as body, flagellum 39-segmented, basal segment 4 times as long as wide, second 0.8 as long as first, third 0.7 as long as first, segments 10-30 transverse and somewhat flattened, wider than basal width of first flagellar segment.

Pronotum rugose, with a moderately strong epomia; mesoscutum very finely punctate, subpolished, notaulices distinct, extending posteriorly about to a line connecting middle of tegulae; scutellar fovea longitudinally striate; scutellum broadly triangular, somewhat flattened, subpolished, and finely punctate; prepectoral carina attaining subalar tubercle; speculum slightly elevated above mesopleura, polished, sparsely punctate; mesopleura and metapleura longitudinally rugose; propodeum rugulose, a vestige of basal transverse carina indicated, apical transverse carina strong, petiolar area 0.8 as long as dorsal face; propodeal spiracle 2.8 times as long as wide.

Areolet slightly convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side equal to first abscissa of cubitus; second recurrent vein simply arched, received in middle of areolet; ramellus present.

Coxae polished, sparsely punctate; hind femur 4 times as long as high, hind tibia 1.3 times as long as hind femur, longer spur of hind tibia 0.45 as long as first segment of hind tarsus; tarsus simple, claw simply pectinate at base, not as long as third tarsal segment. Abdomen finely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carinae weak; second tergite 1.2 times as wide as long, 1.5 times as wide on posterior as on basal margin; third tergite 1.4 times as wide as long; ovipositor sagittate; sheaths of ovipositor not quite as long as tergites 2-4.

Black; scape, abdomen, and legs ferruginous; hind tarsi with segments 2-4 paler; tegulae rufo-piceous; narrow lines on anterior and posterior orbits, clypeus, labrum, mandible except teeth yellowish-white.

Male.—Differs from preceding description of female as follows: pale pubescence on head longer, and more abundant; postocellar line 1.1 times as long as ocell-ocular line, ocell-ocular line 1.2 times diameter of lateral ocellus; antenna broken in allotype, but in paratype 37-segmented; pronotum more finely rugulose; pleura and propodeum more finely punctate, sternaulus somewhat more deeply impressed; propodeal carina indicated but weak; areolet larger and second recurrent vein received in middle; hind femur 6 times as long as high;; longer hind tibial spur 0.3 as long as first segment of hind tarsus; abdomen more slender, first segment with sternite extending posteriorly beyond a line tangential to spiracle; male genitalia (fig. 54); subgenital plate transverse, triangularly produced in middle of posterior margin; parameres with inner margin oblique; digitus gently curved.

Holotype.—Female, Cartville, Trinity Co., altitude 2400-2500 ft., May 30,

1934, probably collected by R. M. or G. E. Bohart, No. 5208 California Academy of Sciences, San Francisco, Calif.

Allotype.—Male, Mt. Tamalpais, California, May 28, 1922, C. L. Fox Collection, California Academy of Sciences, San Francisco, California.

Paratypes.—CALIFORNIA: 1♂, Guerneville, Sonoma Co., May 30, 1910, E. C. VanDyke (CAS); 1♀, Mesa Grande, Sonoma County, June 22 (CU); 1♂, Mill Valley, Marin Co., May 2, 1926, C. L. Fox (CAS); 1♀, Palo Alto, May 13, 1892, R. W. Doane (W); NEVADA: 1♀, bearing typewritten label 4, probably collected in Reno in 1911 by S. B. Doten (USNM); WASHINGTON: 1♀, Red Mt., August 18, 1933, R. D. Shenefelt (USNM).

Remarks.—Very distinct in the female sex because of its stout hind femora and flagellar segments, and the longitudinally rugulose sculpture of the mesopleura.

Cryptus crassipes, new species

Female.—Length 8 mm., ovipositor 2 mm.

Head subpolished, with sparse, silvery-white pubescence; genae polished, finely and sparsely punctate, strongly, somewhat convexly narrowed behind eyes; postocellar line 1.2 times as long as ocell-ocular line; ocell-ocular line 1.2 times as long as diameter of lateral ocellus; occiput shallowly concave, vertex coriaceous; frons shallowly excavated, without a ridge behind each antennal foramen; face about twice as wide as high, punctate, with slight median elevation; clypeus slightly convex, with highly polished, slightly reflexed margin; malar space 0.7 as long as basal width of mandible; mandible much narrowed apically, 1.6 times as long as basal width of mandible; occipital carina well-developed, somewhat flange-like, joining hypostomal carina about 0.6 basal width of mandible from mandible; antenna incrassate in middle, broken in type, fragment 21-segmented; first flagellar segment 3 times as long as wide, second and third segments each slightly shorter than first, fourth segment 0.6 as long as first, segments 15-21 transverse, 1.5 times as wide as long.

Pronotum finely punctate dorsally, irregularly rugulose ventrally, epomia weak; mesoscutum subpolished, finely and densely punctate; notaulices weakly impressed, not extending posteriorly beyond a line tangential to middle of tegulae; scutellar fovea longitudinally rugose; scutellum broadly triangular, polished and finely punctate, scarcely elevated and gradually sloping from base to apex; prepectoral carina complete, attaining subalar tubercles; sternaulus incomplete or very weak anteriorly; mesopleura, metapleura, and propodeum polished and punctate; speculum slightly elevated, polished and impunctate; propodeum with basal transverse carina stronger and complete; propodeal spiracle twice as long as wide.

Areolet large, slightly convergent anteriorly, first intercubitus reclivous, second intercubitus inclivous, anterior side 0.7 as long as first abscissa of cubitus; second recurrent vein simply arched, received beyond middle of areolet; ramellus long.

Legs short and stout; coxae polished and finely punctate; hind femur 4 times as long as high; hind tibia 1.2 times as long as femur; longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tibiae strongly swollen,

basally constricted; tarsal segments normal; claw small, finely pectinate at base, without a large terminal tooth in pecten.

Abdomen finely coriaceous, except first tergite which is polished; side of petiole of first tergite polished and not at all transversely rugose, dorsal carinae absent, postpetiole 3 times as wide as petiole; second tergite 0.7 as wide at basal as at posterior margin; third tergite 0.6 as long as wide; ovipositor sagittate, sheaths as long as tergites 2-4.

Black; scape, dot on each facial orbit below antennal foramina, and median elevation of face, spot on mandible, palpi, tegulae, spot before and beneath tegulae, legs, and abdomen entirely reddish-ferruginous; flagellum black, piceous dorsally in middle; sheaths of ovipositor black.

Holotype.—Female, Cartville, Trinity Co., 2400-2500 ft., May 24, 1934, probably collected by R. M. or G. E. Bohart, No. 5209 California Academy of Sciences, San Francisco, Calif.

Remarks.—The unique female is closely allied to *strigosus* but apparently is distinct in smaller size, shorter flagellar segments and propodeal spiracle, and distinctly convex genae; the pleura lack the strong, longitudinal rugosity of *strigosus* from the same locality.

Cryptus crassulus, new species

Fig. 45

Female.—Length 8 mm., ovipositor 3 mm.

Head with very short, somewhat appressed, silvery-white pubescence; genae slightly narrowed behind eyes, convex, much shorter dorsally than ventrally, subpolished, and finely punctate; ocell-ocular line subequal to postocellar line, 1.6 times as long as diameter of lateral ocellus; frons shallowly excavated, without a strong ridge behind each antennal foramen; face 2.6 times as wide as high, with a median elevation; clypeus evenly convex, with truncate, slightly reflexed margin; labrum projecting; malar space shagreened, subequal to basal width of mandible; mandible 1.8 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.6 as long as body, flagellum 29-segmented, first segment 5 times as long as wide, second slightly shorter, third 0.8 as long as first.

Pronotum finely rugulose laterally, dorsal portion smoother and polished, slightly longitudinally rugulose, epomia strong; mesoscutum subpolished, finely punctate; notaulices deeply impressed, extending posteriorly beyond a line tangential to posterior margins of tegulae; scutellum subpolished, slightly longitudinally aciculate laterally on posterior half; prepectoral carina complete, but weak near subalar tubercle; sternaulus deeply impressed basally, complete; speculum somewhat elevated, smooth and polished, very finely punctate; mesopleura, metapleura, and propodeum irregularly rugulose; propodeum with basal transverse carina complete, but weak; apical carina stronger especially on lateral angles; propodeal spiracle twice as long as wide.

Areolet wider than long, first intercubitus reclivous, second intercubitus inclivous, anterior side about as long as second abscissa of cubitus; second recurrent vein almost straight; ramellus short, nervulus slightly antefurcal.

Coxae subpolished, finely punctate; hind femur 5 times as long as high; hind tibia 1.3 times as long as femur, longer spur 0.3 as long as first segment of hind tarsus; anterior tibia strongly swollen in middle (fig. 45); tarsi simple; claw small, on hind leg as long as fourth segment of tarsus, with fine pecten and bristles at base, but no large terminal tooth in pecten.

Abdomen coriaceous; petiole depressed, coarsely transversely rugulose laterally, dorsal carinae rather strong, fading out beyond spiracles, postpetiole 3 times as wide as petiole; second tergite subequal in length to basal width, posterior margin 1.5 times as wide as basal margin; third tergite 1.7 times as wide as long; following tergite successively shorter and narrower; ovipositor with dorsal valve broken at tip, but probably sagittate; sheaths of ovipositor broken at tip, but, judging by length of ovipositor, as long as tergites 3 and 4.

Black; abdomen, except for base of first tergite, and hind femora reddish-ferruginous; anterior and middle tibiae and tarsi piceous; narrow lines on anterior and posterior orbits and at top of eyes, distal two-thirds of first segment and all of segments 2-4 of hind tarsus, yellowish-white; antenna black with white annulus extending from distal third of third flagellar segment to basal third of tenth flagellar segment.

Holotype.—Female, Quebec, June 3, 1919, J. O. Roy, in collection of Dr. H. K. Townes.

Remarks.—The unique female is very distinct from other Nearctic *Cryptus* in having a complete white annulus on flagellum, in its small number of flagellar segments, and in the form of the anterior tibia (fig. 45).

Cryptus asymmetricus, new species

Figs. 33, 38, 57, 76, 78, 83

Female.—Length 12 mm., ovipositor 4.5 mm.

Head with sparse, long, silvery-brown hairs; genae highly polished and sparsely punctate behind lower two-third of eye, behind upper third of eye closely and densely punctate; post-ocellar line subequal to ocell-ocular line, 1.5 times longer than diameter of lateral ocellus; occiput deeply concave; vertex coriaceous, with sparse punctures; frons deeply excavated, slightly transversely rugulose, without a vertical ridge behind each antennal foramen; face 2.8 times as wide as high, with a median elevation; clypeus strongly convex at base, depressed beyond middle, with a highly polished, slightly reflexed truncate margin; labrum trapezoidal; malar space shagreened, 1.1 times longer than basal width of mandible; mandible 2.2 times as long as basal width of mandible; occipital carina atrophied ventrally at normal point of junction with hypostomal carina; antenna 0.7 as long as body, flagellum 48-segmented, first flagellar segment 4 times as long as wide, second segment 3 times as long as wide and 0.8 as long as first, following segments successively shorter and narrower.

Pronotum longitudinally striate on median dorsal portion, laterally rugulose, with short, weak epomia; mesoscutum smooth, highly polished, very sparsely punctate; notaulices minutely foveolate, extending posteriorly about to a line tangential to posterior margins of tegulae; scutellar fovea longitudinal-

ly striate; scutellum smooth, highly polished, with a few scattered punctures; prepectoral carina incomplete, extending two-thirds distance to subalar tubercle; sternaulus broad, complete, subfoveolate; speculum strongly elevated, highly polished, almost impunctate; mesopleura, metapleura, and propodeum reticulate-rugose, more or less longitudinally rugose-striate above middle and hind coxae; propodeum with only apical carina present, strong, produced laterally, but represented only by strong reticulate ridges directly above hind coxae; posterior face of propodeum abruptly declivous, 1.5 times as long as dorsal face of propodeum; propodeal spiracles elongate, slit-like, 3 times as long as wide.

Coxae densely, granularly punctate dorsally, rest highly polished, sparsely punctate with long, silvery-brown hairs; hind femur 5 times as long as high; hind tibia 1.2 times as long as hind femur, longer tibial spur 0.4 as long as first segment of hind tarsus; anterior femur swollen; fore tarsus strongly swollen and lobate on outer side, lobe on first segment twice as long as lobe on second and third tarsal segments, fourth segment symmetrically bilobed; fifth segment long and slender, 2.5 times as long as fourth segment in middle; segments bearing a variable number of long spines at least as long as first segment in middle (fig. 78).

Areolet slightly anteriorly convergent, first intercubitus slightly reclivous, second intercubitus slightly inclivous, anterior side of areolet subequal to first abscissa of cubitus; second recurrent vein simply arched, received beyond middle of areolet; ramellus conspicuous.

Abdomen finely coriaceous; petiole flattened above and below, transversely rugose laterally, dorsal carinae moderately elevated, area between carinae slightly hollowed out, postpetiole 3 times as wide as petiole, second tergite 1.5 times as broad at posterior margin as long; third tergite twice as wide as long; ovipositor decurved apically, with no dorsal angulation or notch; sheaths of ovipositor as long as tergites 2 and 3.

Black; all femora and abdomen, except petiole bright reddish; anterior tibiae and tarsi reddish-feruginous; middle and hind tibiae and tarsi rufopiceous, posterior tibiae and tarsi darker than middle pair; narrow lines on posterior and anterior orbits, interrupted opposite frons, and a line opposite top of eye, yellowish-white.

Male.—Differs from previous description of female as follows:--postocellar line slightly longer than ocell-ocular line; face 2.5 times as wide as high; mandible twice as long as wide; malar space subequal to basal width of mandible; flagellum 40-segmented; mesoscutum more punctate; mesopleura and metapleura with sculpture less rugose; petiolar area 0.7 as long as dorsal face of propodeum, and basal transverse carina indicated; coxae more densely punctate, tarsi normal, abdomen more slender; subgenital plate and genitalia (fig. 57) very similar to *relativus*.

Black; pale markings on anterior and posterior orbits, dot opposite top of eye, dot in malar space, on middle of clypeus and mandible; hind femur and abdomen beyond middle of first tergite reddish-ferruginous; anterior and middle femora, tibiae and tarsi, and segments 3-5 of hind tarsi, ferruginous.

Holotype.—Female, French Glen, Steen Mts., Oregon, elevation approximately 4300 ft., July 8, 1927, collector probably H. A. Scullen, Cat. No. 55421, U. S. National Museum, Washington, D. C.

Allotype.—Male, Kamloops, British Columbia, June 1, 1938, G. S. Walley, in Canadian National Collection, Ottawa, Canada.

Paratypes.—Specimens have been examined from the following localities: ALBERTA: Calgary; Consort; ARIZONA: Grand Canyon, DunsPlc, San Juan Co., 5500 feet; 20 miles WNW Kayenta; BRITISH COLUMBIA: Chilcotin, Douglas Lake, Kamloops, Mt. Lolo; Fort Steele; Keremeos; Lillooet; Midday Valley; Nicola Lake; Nicola; Okanagana; Oliver; Osoyoos; Vasseau Lake; Vernon; CALIFORNIA: "California," Portola; COLORADO: "Colorado," Ackman; Cortez; Fort Collins; Long's Peak Inn, 9000 feet; Paonia in Delta Co.; IDAHO: Berger; Gooding Co.; Kuna; Malad; MONTANA: Blackfeet Indian Reservation; Helena; East Shore Flathead Lake; Lewis and Clark Co.; McIntyre; Three Forks; NEVADA: "Nevada," Reno; NEW MEXICO: Lake Burford; OREGON: Fish Lake, Steens Mts., 5000 ft.; Frenchglen, Steens Mts., 4300 ft.; Cody Ranch, Harney Co.; Klamath Falls; Warner Lake, Lake Co.; High Tablelands; Virginia Valley; UTAH: Aspen Grove; Mt. Timanogos; Beaver Canyon; Blue Creek; Boyce Canyon; Fort Duchesne; Jordan; Logan Canyon; Magna; Navajo Lake, 9000 ft.; St. George, Washington Co.; Uinta National Forest, Curran Creek Valley, 8000 ft.; WASHINGTON: Lind, Pullman, Yakima; WYOMING: Bridger Basin; Green River; Jenny lake in Grand Tetons. Collections made from May 13 to October 1. Specimens have been swept from sage brush, *Sophia filipes*, and *Pseudotsuga*. Specimens in USNM, CN, CAS, AES, MU, MONT, BS, UTAH, MCZ, TOW, FC, W.

Remarks.—*C. asymmetricus* is a very distinct species in the female sex in the form of ovipositor and anterior tarsi (figs. 78, 83); the male is easily confused with *relativus* and related species. Usually male *asymmetricus* has no distinct vertical ridges on frons behind antennal foramina, occipital carina weak or atrophied at point of normal junction with hypostomal carina, face at least twice as wide as high, mandible at least twice as long as basal width, propodeum with apical transverse carina very strong and arcuate, not at all straight across middle of propodeum, and petiolar area much shorter than dorsal face of propodeum. The coxae and trochanters are black or black and white in some males, but the rest of the legs vary from bright reddish to black.

There is some variation in number of flagellar segments in both sexes. Length 9-17 mm.

Cryptus mirabilis, new species

Female.—Length 12 mm., ovipositor 3 mm.

Very closely related to the preceding species *asymmetricus*, differing structurally from the description of that species as follows: gena less punctate dorsally, flagellum 44-segmented, mesopleura and metapleura much more strongly, longitudinally rugose-striate; postpetiole 3.5 times as wide as petiole; sheath of ovipositor as long as tergites 2-3.

Black, with the following parts reddish-ferruginous: head (except two lines extending from clypeus to antennal foramina, continuous with dark area on frons and area surrounding ocelli, and lower half of malar space which are black), clypeus, labrum, mandible except black base and teeth, scape and pedicel, lateral lobes of mesoscutum, all femora, anterior and middle tibiae

and tarsi, and abdomen except petiole; hind tibiae rufo-piceous; hind tarsi more or less ferruginous.

Holotype.—Female, Cestline, San Bernardino Co., California, May 3, 1936, E. Gordon Linsley, Cat. No. 55423, U. S. National Museum, Washington, D. C.

Remarks.—Described from a unique female. This may represent a reddish phase of *asymmetricus*, but no specimen of that species seen during the present study has the eyes encircled with a broad ferruginous band, or the lateral lobes of the mesoscutum reddish.

Cryptus symmetricus, new species

Figs. 58, 79

Female.—Length 11 mm., ovipositor 3 mm.

Head with sparse, moderately long, silvery-gray pubescence; genae smooth, highly polished behind lower two-thirds of eye, granularly punctate behind upper third of eye, slightly convexly narrowed behind eyes; postocella line subequal to ocell-ocular line, 1.2 times longer than diameter of lateral ocellus; occiput deeply concave; vertex densely punctate; frons rugulose, deeply excavated, with a vertical ridge behind each antennal foramen; face 2.5 times as wide as high, with a median elevation; clypeus convex with a narrow, highly polished, slightly reflexed margin; labrum projecting; malar space shagreened, subequal to basal width of mandible; mandible twice as long as basal width; occipital carina complete. joining hypostomal carina; antenna 0.7 as long as body, flagellum 42-segmented, basal segment 5 times as long as wide, second segment 0.8 as long as first segment, following segments shorter and narrower.

Pronotum rugulose, with trace of epomia; mesoscutum smooth, highly impressed, extending posteriorly to a line connecting middle of tegulae; scutellar fovea longitudinally rugose; scutellum smooth, highly polished with a few polished, very sparsely punctate; notaulices minutely foveolate, not deeply scattered punctates, elevated anteriorly and sloping gradually posteriorly; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete, subfoveolate; speculum shining, elevated, impunctate; mesopleura, metapleura, irregularly longitudinally striate-rugose; propodeum reticulately rugulose, only a trace of basal transverse carina, apical transverse carina present, strongest laterally, but represented above hind coxae only by strongly reticulate ridges; propodeal spiracle elongate, slit-like, 3 times as long as wide.

Legs with coxae densely and granularly punctate dorsally, rest highly polished and sparsely punctate, with sparse, silvery-white hairs; hind femur about 5 times as long as high; hind tibia 1.3 times longer than hind femur, longer hind tibial spur about 0.4 as long as first segment of hind tarsus; anterior femur swollen; anterior tarsal segments strongly swollen (fig. 79); second, third, and fourth segments bilobed with lobes on inner side slightly longer than those on outer side, each lobe bearing several very long spines as long as median length of segments 2 and 3 together; claws long, pectinate at

base, with one, longer, terminal tooth in pecten; middle tarsi expanded, spines shorter than median length of segments.

Areolet slightly anteriorly convergent, anterior side as long as first abscissa of cubitus, first intercubitus reclivous, second intercubitus inclivous; second recurrent vein received slightly beyond middle of areolet, simply arched.

Abdomen very finely coriaceous; petiole flattened above and below, irregularly transversely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carinae rather strong; second tergite 1.5 times as wide on posterior as on basal margin; third tergite twice as wide as long; ovipositor decurved, without dorsal angulation or notch; sheaths 1.5 times longer than first tergite.

Black; fore and middle tibiae and tarsi and last four segments of hind tarsus rufo-piceous; abdomen, except petiole, and all femora reddish; narrow lines on anterior orbits, interrupted opposite frons, posterior orbits, and dot at top of eyes, yellowish-white; wings dilutely, but uniformly infumate, veins and stigma dark piceous; sheaths of ovipositor black.

Male.—Differs from preceding description of female as follows: pubescence of head more abundant and longer, face twice as wide as high; malar space 0.8 as long as basal width of mandible; antennae broken at tips, but fragment of flagellum 32-segmented; pronotum more punctate, less rugulose, epomia stronger; mesoscutum more densely punctate; mesopleura, metapleura, and propodeum more reticulately rugulose, propodeal carina weaker, barely indicated; tarsi normal; abdomen more slender, first segment with sternite extending posteriorly as far as a line tangential to posterior margin of spiracle; male subgenital plate and genitalia (fig. 58); the subgenital plate longer and narrower than in *relativus* Cresson.

Black; pale markings on posterior and anterior orbits, dot opposite top of eye, dot in middle of face and clypeus, mandible except extreme base and teeth, scape beneath, spots on anterior and middle coxae and trochanters, and segments 2-4 of hind tarsi; hind femur and abdomen except petiole reddish-ferruginous; anterior and middle femora, tibiae, and tarsi rufo-piceous, femora with black line beneath.

Holotype.—Female, Beaver Range Mts., Utah, 8-10,000 feet, Cat. No. 55422, U. S. National Museum, Washington, D. C.

Allotype.—Male, Pullman, Washington, June 1921, Doyle Starcher, Washington State College, Pullman, Washington.

Paratypes.—(all female) from following localities: ALBERTA: Banff, July 1, 1925, Owen Bryant (USNM); ARIZONA: Kaventa, 19 mi. SW, June 19, 1933, Navajo Co., 6500 ft., H. N. Hultgren (CAS); BRITISH COLUMBIA: Lilloet, April 27, 1923, E. R. Buckell (CN); UTAH: Navajo Lake, 9000 ft., June 17, 1940, R. M. Bohart (UCLA); South Creek, Beaver Co., (USNM); Strawberry Valley, July 22, 1934, E. W. Anthon (UTAH).

Remarks.—*C. symmetricus* is similar in general coloration to *relativus* Cresson, but the decurved ovipositor and very strongly bilobed anterior tarsi immediately distinguish the female. The strong occipital carina and form of the anterior tarsi easily distinguish *symmetricus* from *asymmetricus*. The coxae and trochanters are black, but the rest of the legs vary from reddish-ferruginous

to nearly black. A series of several males and 1 female taken by R. M. Bohart at Navajo Lake, Utah, suggest very strongly that *symmetricus* is closely allied, perhaps a red-legged female, of *leucopus* Ashmead. Until a better series is available, however, it seems wisest to consider the two species separately.

Cryptus bilobatus, new species

Female.—Length 14 mm., ovipositor 4 mm.

Differs from the preceding description of *symmetricus* as follows: flagellum 46-segmented, coxae less punctate on dorsal surface.

Black; abdomen and legs entirely reddish; hind tibia and first segment of hind tarsus infuscated, segments 2-4 of hind tarsus yellowish-white; clypeus medially, mandible except black base and teeth, and scape reddish-ferruginous; narrow lines on posterior orbits and dot opposite top of eye, yellowish-white; wings very deeply infuscate, veins and stigma black.

Holotype.—Female, Carrville, Trinity Co., California, 2400-2500 ft., June 2, 1934, G. E. Bohart, No. 5210 California Academy of Sciences, San Francisco, California.

Paratypes (all female).—CALIFORNIA: Carrville, Trinity Co., 2400-2500 ft., June 15, 1934, E. C. Van Dyke (MU); Fallen Leaf Lake, El Dorado Co., July 1931, O. H. Swezey (CAS); Gold Lake, Sierra Co., July 20, 1921, C. L. Fox (CAS). OREGON: Eagle Ridge, Klamath Lake, May 27, 1924, C. L. Fox (CAS).

Remarks.—*C. bilobatus* appears to be restricted to California and Oregon. In the *symmetricus* group its reddish legs make it a very distinct species.

CRYPTUS LEUCOPUS Ashmead

Figs. 77, 80

Cryptus leucopus Ashmead, 1890, Proc. U. S. Nat. Mus., **12**:409, male.

Male.—Length 14 mm.

Head with sparse, moderately long, silvery-gray pubescence; genae smooth, highly polished, behind lower two-thirds of eye, granularly punctate behind upper third of eye, slightly convexly narrowed beyond eyes; postocellar line subequal to ocell-ocular line, 1.4 times diameter of lateral ocellus; occiput deeply concave; vertex coriaceous, ocellar triangle punctate; frons deeply excavated with a ridge behind each antennal foramen; face 1.9 times as wide as high, with a median elevation; clypeus convex with a thin, highly polished, slightly reflexed margin; labrum projecting; malar space shagreened, subequal to basal width of mandible; mandible twice as long as basal width; occipital carina complete, joining hypostomal carina; antenna 0.7 as long as body, flagellum 46-segmented, first segment 3 times as long as wide.

Pronotum punctate, with a trace of epomia; mesoscutum polished and finely punctate, punctures separated from each other; notaulices minutely foveolate, not deeply impressed, extending posteriorly to a line connecting

middle of tegulae; scutellar fovea longitudinally rugose; scutellum smooth, highly polished with a few scattered punctures; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete, subfoveolate; speculum shining, elevated, sparsely and finely punctate; mesopleura, metapleura, and propodeum coarsely and confluently punctate; propodeum with apical transverse carina present but not strong, very weak in middle and arcuate in middle, not straight; propodeal spiracle elongate, slit-like, 3 times as long as wide.

Legs long and slender, coxae densely, granularly punctate dorsally, rest highly polished and sparsely punctate, with sparse, silvery-white hairs; hind femur 6 times as long as high; hind tibia 1.3 times as long as femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; claw 0.7 as long as third tarsal segment; claw pectinate at base with large, terminal tooth in pecten.

Areolet slightly anteriorly convergent, anterior side as long as first abscissa of cubitus, first intercubitus reclivous, second intercubitus inclivous; second recurrent vein received slightly beyond middle of areolet.

Abdomen very finely coriaceous, first tergite polished, postpetiole twice as wide as petiole, sternite extending posteriorly to a line tangential to spiracle; petiole not transversely rugose laterally; second tergite almost 2.5 times as long as basal width; following tergites successively shorter and narrower; male genitalia with apical margin arcuate and darker than base, subgenital plate transverse, apical portion of cuspis distinctly broader than basal portion; subgenital plate and genitalia (figs. 77 and 80).

Black; orbits, median elevation of face, clypeus in middle, broad anterior orbits including malar space, narrow posterior orbits, spot on mandible, second segment of maxillary palpus, spot on trochanter, base of hind femur, and hind tarsal segments 2-5 all yellowish-white; abdomen reddish beyond first tergite; anterior femur ventrally and more or less of anterior and middle tibiae rufopiceous.

Holotype.—Male, Colorado, through C. V. Riley, Cat. No. 2022, U. S. National Museum, Washington, D. C.

Distribution.—BRITISH COLUMBIA: Nicola, May 17, 1923, E. R. Buckell (CN); COLORADO: Campus of University of Colorado, Boulder (USNM); Cortez, May 10, 1925 (FC); Golden, May 28 (USNM). UTAH: Beaver Canyon (USNM) Buckskin Valley, Iron Co. (MU); Navajo Lake, 9000 ft., June 17, 1940, R. M. Bohart (UCLA, MU).

Remarks.—*C. leucopus* is closely allied to, perhaps only the male of, *symmetricus*. In the small amount of material available, the color of the hind femora seems to be constantly black in *leucopus* and reddish in *symmetricus*, and, for this reason, the two species are treated separately. The type of *leucopus* is allied to the male of *relativus* Cresson, but the black hind femora, less strongly punctate mesoscutum, propodeum with weaker carinae, and malar space shorter than to as long as basal width of mandible should aid in separating the two species. The pale pubescence and pale segments 2-4 of the hind tarsus should separate *leucopus* from the male of *dirus* Cresson which has dark pubescence and, usually, entirely black tarsus.

Cryptus serraticaudus, new species

Figs. 59, 84

Female.—Length 15 mm., ovipositor 10 mm.

Head subpolished, finely punctate, clothed with short, somewhat appressed whitish pubescence; genae subpolished finely and sparsely punctate, slightly convexly narrowed behind eyes, occiput deeply concave; ocell-ocular line 1.5 times as long as post-ocellar line, post-ocellar line 1.2 times as long as diameter of lateral ocellus; eyes parallel, slightly sinuate above antennal foramina; frons deeply excavated, slightly transversely rugulose near antennae without a vertical ridge behind antennal foramen; face 2.2 times as wide as high; clypeus convex, with a narrow, highly polished, slightly reflexed margin; labrum projecting, trapezoidal; malar space shagreened, slightly longer than basal width of mandible, mandible twice as long as basal width, teeth subequal; occipital carina joining hypostomal carina less than basal width of mandible; antenna 0.7 as long as body, flagellum 51-segmented, first flagellar segment 5.5 times as long as wide, second 0.7 as long as first, third 0.5 as long as first.

Pronotum punctate dorsally, slightly rugulose ventrally, epomia present but weak; mesoscutum subpolished, densely punctate, notaulices indicated, but not deeply impressed, fading out just before a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum subpolished, finely punctate, sloping gradually toward apex; prepectoral carina extending 0.7 distance to subalar tubercle, curving anteriorly at this point and meeting pronotal suture; sternaulus complete, broad, deeply impressed at base, subfoveolate; speculum somewhat elevated, polished and slightly punctate; mesopleura, metapleura, and propodeum rugulose, subpolished; propodeum with only apical transverse carina present, strongest laterally and reduced to irregular, reticulate ridges above coxae; dorsal face 0.7 as long as petiolar area; propodeal spiracle 3.5 times as long as wide.

Coxae densely punctate dorsally, the rest polished and moderately punctate with short, silvery hairs; hind femur 5 times as long as high, hind tibia 1.2 times as long as hind femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tarsal segments somewhat expanded and with spines about 0.5 as long as median length of third tarsal segment.

Areolet slightly convergent anteriorly, first intercubitus reclivous, second intercubitus inclivous; second recurrent vein simply arched, received slightly beyond middle of areolet, ramellus present.

Abdomen finely coriaceous; petiole flattened dorsally and ventrally and somewhat polished, granulate laterally especially at base, postpetiole 3 times as wide as petiole; second tergite with posterior margin 1.5 times as wide as base, 1.5 times as wide at posterior margin as long; third tergite twice as wide as long; following tergites transverse, each shorter than previous one; ovipositor as long as abdomen, compressed, scimitar-shaped, with about 14 coarse teeth on ventral margin, sheaths of ovipositor subequal in length to abdomen (fig. 84).

Entirely ferruginous; ovipositor sheaths black; flagellar segments beyond first increasingly fuscous; wings deep brown with a brassy reflection.

Male.—Essentially like female, differs in usual sexual characters: ocell-ocular line being subequal to post-ocellar line; genae more coarsely punctate; mesopleura slightly diagonally rugulose; metapleura very coarsely punctate, abdomen more slender with postpetiole only twice as wide as petiole. Ferruginous with the following parts black: antennae, except scape, occiput, vertex frons, posterior margin of genae, a line beneath each antennal foramen joining one in clypeal suture, depressed portion of pronotum, all sutures of mesothorax and metathorax, most of mesopleura, metapleura, and all of propodeum, dorsal spot on each coxa, and a line on dorsal surface of hind tibia; segments 2-4 of hind tarsus yellowish; subgenital plate and genitalia (fig. 59).

Holotype.—Female, Siskiyou Pass, Jackson Co., Oregon, 4500 feet, July 15, 1930, H. A. Scullen, Cat. No. 55420, U. S. National Museum, Washington, D. C.

Allotype.—Male, Eureka, Utah, June 14, 1820, Tom Spaulding, in American Museum of Natural History, New York, New York.

Paratypes.—BRITISH COLUMBIA: Keremeos; Nicola Lake; Vernon. CALIFORNIA: Big Flat, Coffee Creek, Trinity Co.; Keddie. OREGON: Klamath Falls; Olene; Siskiyou Pass, Jackson Co. UTAH: Consumers; Eureka; Heber. WASHINGTON: Touchet. Specimens in USNM, CN, CAS, AMNH, MU, OR, UCLA, collected from May to September.

Remarks.—Very distinct in the female because of its very large size, and strongly serrate ovipositor. The male is less distinct, but should be recognized by its color and the long, narrow digitus of the male genitalia as well as by the key characters. Size 13-18. The amount of black in the male is subject to considerable variation.

CRYPTUS TEJONENSIS Cresson

Fig. 61

Cryptus tejonensis Cresson, 1878, Proc. Acad. Nat. Sci.: 360, female.
Cryptus vancouverensis Harrington, 1894, Can. Ent., **25**:211, female.

Female.—Length 15 mm., ovipositor 6 mm.

Head with short, somewhat appressed, silvery-white pubescence; genae subpolished, densely but finely punctate, moderately narrowed behind eyes and slightly convex; ocell-ocular line subequal to post-ocellar line, 1.2 times diameter of lateral ocellus; occiput deeply concave; vertex granularly punctate; frons moderately excavated, without a vertical ridge behind each antennal foramen, but coarsely rugulose, almost transversely so ventrally; face 2.2 times as wide as high, with a median elevation; clypeus elevated at base, abruptly declivous beyond middle, with a thin, highly polished margin; labrum projecting; malar space 0.9 basal width of mandible; mandible 1.3 times as long as basal width of mandible; occipital carina joining hypostomal carina at a distance slightly less than basal width of mandible from mandible; antenna broken in type, about 40-segmented in other specimens, first flagellar segment 5.5 times as long as wide, second 4 times, third 3 times as long as wide.

Pronotum rugulose, with epomia present but weak; mesoscutum densely and finely punctate; notaulices strong to a line opposite posterior margin of tegulae; scutellar fovea longitudinally striate; scutellum convex, finely punctate, not at all margined at base; prepectoral carina complete, attaining subalar tubercle; sternaulus complete; mesopleura, metapleura, and propodeum reticulate-rugulose; speculum elevated, polished, very weakly punctate; propodeum with only apical transverse carina complete, a trace of basal transverse carina indicated; propodeal spiracle 3 times as long as wide.

Legs rather long and slender, all coxae subpolished, densely punctate, with short, pale pubescence; hind femur 6 times as long as high, hind tibia 1.2 times as long as hind femur, longer spur of hind tibia 0.3 times as long as first segment of hind tarsus; anterior tarsus very slightly expanded; claw large, as long as median length of third tarsal segment of anterior leg, pectinate at base, pecten ending in one large, terminal tooth.

Areolet slightly anteriorly convergent, first intercubitus slightly reclivous, second intercubitus inclivous, anterior side of areolet slightly longer than either abscissa of cubitus; second recurrent vein simply arched, received about in middle of areolet.

Abdomen finely coriaceous, subpolished, petiole depressed, somewhat transversely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carina indicated, but not strong; second tergite about twice as wide at posterior margin as long; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-4.

Head and thorax black; clypeus, labrum, mandible except teeth, scape, scutellum obscurely, legs and abdomen entirely reddish-ferruginous; tegula rufo-piceous; hind tibia and first segment of hind tarsus somewhat obfuscated; pale yellowish-white lines on anterior orbits opposite antennae, a large dot opposite top of eye, and narrow line on posterior orbits; hind tarsal segments 2-4 dirty white; wings dilutely infumate, stigma and veins fuscous.

Male.—Differs from preceding description of female as follows: Length 11 mm. Post-ocellar line 1.5 times diameter of lateral ocellus; face twice as wide as high; occipital carina joining hypostomal carina 0.8 basal width of mandible from mandible; flagellum 40-segmented, first flagellar segment 2.5 times as long as wide; mesopleura, metapleura, and propodeum coarsely, confluently punctate; propodeum with trace of basal transverse carina, apical carina complete and strong; hind tibia 1.4 times longer than hind femur, longer spur of hind tibia 0.4 as long as first segment of hind tarsus; abdomen more slender, petiole with sternite extending posteriorly to a line tangential to spiracle; postpetiole 2.2 times as wide as petiole; male subgenital plate and genitalia (fig. 61), inner margin of paramere oblique, slightly emarginate; subgenital plate with posterior margin rounded.

Black; legs and abdomen reddish-ferruginous; scape beneath, orbits, except behind top of eye, face, except for an irregular black line extending from base of mandible through tentorial pit to antennal foramen on either side of face, spot on anterior margin of tegula, subalar tubercle, and spot before subalar tubercle, all of hind tarsus, yellowish-white.

Lectotype.—Female, Fort Tejon, California, No. 1163, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Palo Alto, California, May 12, 1921, in American Museum of Natural History, New York, New York.

The type of *Cryptus vancouverensis* Harrington is No. 130 in Canadian National Collection, Ottawa, Ontario, Canada.

Distrbution.—BRITISH COLUMBIA: type and 2 female paratypes of *vancouverensis* from Victoria, Vancouver Island; one other female from Victoria; CALIFORNIA: Berkeley; Canby; Mill Valley, Marin Co.; Monterey; Yosemite Valley. Also 1 female Mt. View, Erhorn Lot 2 in USNM without any state locality. Specimens in CN, AES, CAS, USNM, CU, MU. Collected from April to July.

Remarks.—*C. tejonensis* as recognized in this paper is confined to the Pacific Coast region from Monterey north to Vancouver Island, British Columbia. Inland it occurs in the central valley of California from Fort Tejon to Canby, Modoc Co. The shallowly excavated frons without the usual strong, vertical ridge behind each antennal foramen, the very wide face, short malar space, and broad mandible, together with the fact that the males have the inner margin of the paramere distinctly emarginate, serve to distinguish this species from all other Nearctic species of *Cryptus* with red legs and abdomen. It is most likely to be confused with the male of *pacificus* Cresson. Females vary from 11-16 mm. long with ovipositors 3-6 mm. long. The proportions of the mandible, malar space, and the strength of the epomia and propodeal carinae vary slightly.

Cryptus rufopedibus, new species

Length 16 mm., ovipositor 6 mm.

Head coriaceous with short, somewhat appressed, silvery-white pubescence; genae subpolished, densely but finely punctate, distinctly narrowed behind eyes and slightly convex; ocell-ocular line subequal to post-ocellar line 1.3 times as long as lateral ocellus; occiput deeply concave; vertex granularly punctate, more strongly so in ocellar triangle; frons deeply excavated with a strong ridge behind each antennal foramen, rugulose dorsally, polished ventrally; face twice as wide as high, with a median elevation; clypeus strongly convex basally, depressed beyond middle, with a narrow highly polished margin; labrum projecting; malar space 1.1 times basal width of mandible; mandible 1.6 times long as basal width; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 47-segmented, basal segment 5.5 times as long as wide, second segment shorter, third and fourth segments together as long as first, following segments successively shorter and narrower.

Pronotum rugulose, with strong epomia; mesoscutum finely and densely punctate; notaulices strong to a line tangential to posterior margin of tegulae; scutellar fovea longitudinally rugulose; scutellum polished, finely punctate; prepectoral carina complete, attaining subalar tubercle; but weak dorsally: sternaulus complete, attaining pleural suture; mesopleura, metapleura, and propodeum irregularly rugulose; speculum elevated, sparsely and finely punctate; apical transverse carina of propodeum complete, a trace of basal trans-

verse carina indicated on disc of propodeum and a small truncately triangular area between basal carina and base of propodeum; propodeal spiracle 3.5 times as long as wide.

Legs rather long and slender; coxae subpolished and densely punctate, with short, pale pubescence; hind femur 5 times as long as high; hind tibia 1.3 times as long as hind tibia, longer spur 0.4 as long as first segment of hind tarsus; anterior tarsus slightly expanded; claw large, as long as third segment of anterior tarsus, pectinate at base with one large terminal tooth in pecten.

Areolet large, sides subparallel, first intercubitus slightly reclivous, second intercubitus strongly inclivous, anterior side as long as second abscissa of cubitus; second recurrent vein simply arched, received in middle of areolet; ramellus strong; nervulus insterstitial.

Abdomen finely coriaceous; petiole depressed, somewhat transversely rugulose laterally, postpetiole 3 times as wide as petiole; dorsal carinae merely indicated; second tergite 1.4 times as long as basal width, posterior margin twice as wide as basal margin; third tergite 1.9 times as wide as long; ovipositor sagittate, with tiny notch in dorsal angulation; sheaths of ovipositor as long as tergites 2-4.

Head and thorax black; scape beneath, abdomen and legs reddish-ferruginous; base of first tergite, hind tibia and first segment of hind tarsus infuscated; narrow lines on anterior and posterior orbits and opposite top of eye, and segments 2-4 of hind tarsus yellowish-white; clypeus, labrum, mandible, and scutellum obscurely ferruginous; wings hyaline tinged with fuscous, veins and stigma piceous.

Holotype.——Female, Pullman, Washington, July 10, 1898, C. V. Piper, Cat. No. 55426, U. S. National Museum, Washington, D. C.

Paratypes.—2 ♀, bearing typewritten label "186" and "18" (MU, USNM). These were probably collected by S. D. Doten in Reno, Nevada in summer of 1911, the specimens living 186 and 18 days respectively in captivity.

Remarks.—*C. rufopedibus* is closely allied in color pattern to *pacificus* Cresson (male only), *tejonensis* Cresson, *ocellaris* Pratt, and *rufovinctus* Pratt. The simply arched recurrent vein separates the first four species from *rufovinctus*, while the strong, vertical ridge behind the antennal foramen will separate *rufopedibus* from *tejonensis* and *ocellaris*. The female of *pacificus* is ferruginous with stongly expanded anterior tarsal segments.

Cryptus pacificus, Cresson

Fig. 60

Cryptus pacificus Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 361, male.
Cryptus punicus Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 364, female (not male). (New synonymy).
Cryptus californicus Ashmead, 1890, Proc. U. S. Nat. Mus., **12**: 411, female. New synonymy.

Female.—Length 13 mm.; ovipositor 6 mm.

Head with sparse, short, somewhat appressed silvery-white pubescence; gena polished, very sparsely punctate, slightly convexly narrowed behind eye;

ocell-ocular line slightly longer than post-ocellar line, ocell-ocular line 1.8 times as long as diameter of lateral ocellus; occiput deeply concave; vertex punctate with both black and silvery-white pubescence; frons deeply excavated with a distinct ridge behind each antennal foramen; face twice as wide as high, with a prominent median elevation; clypeus convex, with narrow, highly polished, slightly reflexed margin; labrum projecting; malar space shagreened, 1.3 times as long as basal width of mandible; mandible 1.9 times as long as basal width; occipital carina complete, joining hypostomal carina slightly more than basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 51-segmented; first segment of flagellum 5.5 times as long as wide, second 0.7 as long as first, third 0.5 as long as first.

Pronotum finely rugulose dorsally, increasingly rugose in middle and lower portion, with distinct epomia; mesoscutum polished, finely and densely punctate, notaulices extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally rugose; scutellum polished, finely punctate; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete, impressed at base, subfoveolate; speculum strongly elevated smooth, shining, almost impunctate; mesopleura, and propodeum rugulose, metapleura often obliquely rugose; propodeum with apical transverse carina present, strongest on lateral angles; basal transverse carina vestigal or entirely absent; propodeal spiracle 3.5 times as long as wide, slit-like.

Coxae polished, sparsely punctate with short, silvery-white pubescence; hind femur 5 times as long as high, slightly constricted distally; hind tibia 1.3 times as long as hind femur; longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tarsus expanded symmetrically, with variable number of spines on each tarsal segment; claw large, 0.8 as long as third segment of hind tarsus, with one, large terminal tooth in pecten.

Areolet large, very slightly anteriorly convergent, first intercubitus slightly reclivous, second intercubitus slightly inclivous, anterior side longer than either abscissa of cubitus; second recurrent vein almost straight, received slightly beyond middle of areolet; ramellus long.

Abdomen polished, finely coriaceous; petiole flattened dorsally and ventrally, polished except laterally where petiole is transversely rugulose, postpetiole 3 times as wide as petiole, dorsal carinae present; second tergite with posterior margin 1.5 times as wide as basal margin; and 1.3 times as wide as tergite is long; third tergite almost twice as wide as long, shorter than second tergite; following tergites transverse, successively shorter and narrower; ovipositor sagittate, with about 10 fine teeth on ventral margin; sheaths of ovipositor as long as tergites 2-5.

Entirely ferruginous; ovipositor sheaths and flagellum more or less fuscous; wings deep brown yith a brassy reflection.

Male.—13 mm. long. Differs from preceding description of female as follows: head with more abundant and longer pubescence; gena not so strongly narrowed behind eye, ocell-ocular line 1.6 times as long as diameter of lateral ocellus, malar space 0.8 as long as basal width of mandible, mandible 1.5 times as long as basal width of mandible; flagellum broken in type, but more than

43-segmented, 48-52 segmented in other specimens; mesoscutum and scutellum more densely punctate; mesopleura, metapleura, and propodeum densely punctate, not rugose; propodeal spiracle 3 times as long as wide; basal and apical transverse carina present, of about same strength; hind femur 6 times as long as high, tarsi simple, claw about as long as fourth segment of hind tarsus; abdomen more slender; postpetiole about twice as wide as petiole, with slight median depression on postpetiole posterior to spiracles; second tergite 4 times as long as basal width and at least twice as long as width of posterior margin; male subgenital plate and genitalia (fig. 60).

Black; legs, including coxae, and abdomen entirely reddish-ferruginous; narrow lines on posterior orbits, on vertex opposite top of eye, broad anterior orbits, spot on middle of face, clypeus, and most of mandible, most of palpi, segments 2-4 of hind tarsus, spots on anterior and middle trochanters, and anterior coxae, yellowish-white; tegula reddish anteriorly, darker posteriorly; posterior tibia infuscated distally, first segment of hind tarsus infuscated.

Lectotype.—Male, California, No. 1145.1, Academy of Natural Sciences, Philadelphia, Pa.

Female.—The lectotype of *punicus* Cresson, California, No. 1152, Academy of Natural Sciences, Philadelphia, Pa.

The type of *californicus* Ashmead is No. 2029, U. S. National Museum, Washington, D. C.

Distribution.—Specimens have been examined from the following localities: BRITISH COLUMBIA: Anderson Lake; Fish Lake; New Castle Islands; Hope Summit; Oliver; CALIFORNIA: Angora Peak, Tahoe; Bass Lake, Modoc Co.; Big Bear Lake, San Bernardino Mts.; Big Flat, Coffee Creek, Trinity Co.; Bird Lake, Tulare Co.; Carson Pass, 800 ft.; Cayton, Shasta Co.; Convict L.; Coalinga, Fresno Co.; Davis Creek, Modoc Co.; Fallen Leaf Lake, El Dorado Co.; Forest Home, San Bernardino Co.: Giant Forest; Gold Lake, Sierra Co.; Huntington, Fresno Co.; King's R. Cyn, Fresno Co.; Lake City, Modoc Co.; Lone Pine, Inyo Co.; Los Angeles; Mammoth; Meadow Valley, Plumas Co., 3500-4000 ft.; Mill Creek, San Bernardino Co.; Mineral Ring; Mt. Diablo; Mono, 10,600 ft.; Ora Grande; Owen's Valley, Inca Co.; San Bernardino; Shasta Springs, Shasta Co.; Sonoma Co.; Strawberry Valley, El Dorado Co.; Summit, Placer Co.; Tahoe, Toga Pass, Topaz; Truckee; Trinity Co. NEVADA: Reno. OREGON: Bly; Corvallis; Crater Lake Park, 6000 ft.; Drake Park Lake, 7000 ft.; Eagle Ridge, Klamath Lake; Steens Mts.; Klamath Falls. WASHINGTON: N. Yakima; Toppenish; Bogacheil Mt., Olympus, 5000 ft. Collected from June 1 until August 28. Specimens in USNM, GAS, CN, AES, MU, BC, UCLA, CU, OR, W.

Remarks.—This is the only Nearctic species of *Cryptus* with marked color antigeny or sexual dichromatism. The above synonymy is based upon a careful study of all types and paratypes, a gynandromorph in the collection of the American Entomological Society, and a series of males and females collected in California and Oregon in the same localities on the same dates. The types of *punicus* Cresson and *californicus* Ashmead, both females, are entirely conspecific. A careful study of the gynandromorph of *C. pacificus* in the collection of the American Entomological Society and of the types of *pacificus* and *punicus* indicates that *punicus* is the female of *pacificus*. The male which Cresson described with *punicus*, paratype 1152.4, belongs near *Compsocryptus pur-*

puripennis (Cresson) because of its weakly impressed notaulices, ramellus being absent, and because of its uniformly dark wings.

The specimens of *C. punicus* recorded by Ashmead (1900) and Viereck (1910) from New Jersey are far east of the normal range of the true *punicus* Cresson. These specimens appear to be lost. These records from New Jersey probably should pertain, like Ashmead's record of *Cryptus retentor* Brulle, to some genus near *Aptesis* in the tribe Phygadeuonini.

There is considerable variability in the female. The tarsi may be almost simple or very strongly expanded and spinose; the flagellum may be black or almost entirely ferruginous; usually the smaller specimens have the tarsi less expanded than large specimens. In the male the amount of yellowish markings on the head and legs is very variable, as is the width of the subgenital plate.

Cryptus robustus, Cresson

Figs. 34, 39, 49, 62

Cryptus robustus Cresson, 1864, Proc. Ent. Soc. Phil., **3**:289, no. 1, female.—Cresson, 1865, Proc. Ent. Soc. Phil., **4**:265, no. 1, female.—Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, pt. 1: 72, female.—Provancher, 1882, Nat. Can., **13**: 361, no. 30, female.—Provancher, 1883, Pet. Faun. Ent. Can. Hym., **2**: 783, no. 30, female.—Criddle, 1928, 58th Ann. Rept. Ent. Soc. Ont.: 102.

Cryptus crassicornis Cresson, 1864, Proc. Ent. Soc. Phil., **3**:292, no. 5, male.—Cresson, 1865, Proc. Ent. Soc. Phil., **4**:265, no. 5, male.

Female.—Length 13 mm.; ovipositor 6 mm.

Head very minutely coriaceous, densely punctate on vertex and highly polished on genae, with erect, shining, brown pubescence; gena almost as long as eye in lateral view, finely punctate, slightly convexly receding behind eye; ocell-ocular line slightly longer than post-ocellar line, and nearly twice diameter of lateral ocellus; occiput deeply concave; frons deeply excavated, rugulose above and transversely striate below, with very slight vertical ridge behind each antennal foramen; face twice as broad as high, with a slight, median elevation clypeus convex, with slightly reflexed, highly polished apical margin; labrum exserted, arcuately trapezoidal; malar space shagreened, 1.5 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 50-segmented, first flagellar segment 6 times as long as wide, about as long as second and third segments together: following segments successively shorter and narrower.

Pronotum rather densely punctate along dorso-posterior margin, rugulose below, with epomia weak; mesoscutum shining, densely punctate, notaulices strong, extending posteriorly as far as a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum polished, finely punctate, sloping gradually to apex; prepectoral carina extending about 0.7 distance to subalar tubercle; sternaulus complete, but weak posteriorly; mesopleura finely rugulose above, often more oblique striate-rugulose above middle coxa; speculum strongly elevated, highly polished, almost impunctate; metapleura and propodeum finely rugulose, somewhat irregularly, obliquely striate above hind

coxa; propodeum with only apical transverse carina present, and complete; a trace of basal transverse carina; propodeal spiracle 3 times as long as wide.

Legs rather stout, all coxae highly polished, sparsely punctate, with sparse shining, brownish pubescence; all femora stout and conspicuously constricted distally; hind femur 4 times as long as high, somewhat compressed, with distinct ventral ridge (fig. 49); hind tibia 1.2 times as long as hind femur; longer spur of hind tibia 0.4 times as long as first segment of hind tarsus; anterior and middle tarsi strongly and symmetrically expanded, fourth segment bilobed. longest spines on middle tarsal segments about as long as median length of third tarsal segment; claw about as long as median length of third tarsal segment, pectinate at base, pecten ending in one large, terminal tooth (fig. 34).

Areolet large, first intercubitus almost perpendicular, second intercubitus inclivous, anterior side longer than either abscissa of cubitus; second recurrent vein simply arched, received slightly beyond middle of areolet; ramellus long, (fig. 39).

Abdomen robust, finely coriaceous; petiole flat, broader than deep at base. polished dorsally, laterally polished to rugulose, punctate ventrally, dorsal carina strongly elevated but fading out opposite spiracle; second tergite 0.7 as long as first, 1.5 times as wide at posterior margin as long; third tergite twice as wide as long; following tergites transverse, successively shorter and narrower; ovipositor sagitate, as long as tergites 2-5 or 2-6.

Black; anterior orbits antennal fossa, a dot at top of eye, and narrow posterior orbits, yellowish-white; scape rufo-piceous beneath; legs beyond trochanters ferruginous; abdomen black with a bluish reflection; wings uniformly and dilutely infumate, stigma and veins black.

Male.—15 mm. antenna 12 mm.

Differs from preceding description of female as follows: genae more coarsely punctate; malar space subequal to basal width of mandible; basal flagellar segments subequal; longitudinal carina in petiolar area stronger; tarsi simple; hind femur swollen and constricted at tip, with at most a trace of ventral ridge; petiole with dorsal carina very weak, sternite extending posteriorly to a line opposite spiracle, postpetiole about twice as wide as petiole; abdomen more slender, second tergite about as long as wide, slightly longer than third tergite.

Color as in female, except that anterior orbits are longer, extending to malar space and are somewhat wider opposite malar space; male genitalia and subgenital plate (fig. 62). The apically narrowed paramere and subgenital plate with posterior margin produced in middle appear to have some specific value.

Lectotype.—Female, Colorado, No. 1157, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Lectotype of *crassicornis* Cresson, Colorado No. 1132.1 Academy of Natural Sciences, Philadelphia, Pa.

Distribution.—ALASKA: Skagway. ALBERTA: Banff; Calgary; Waterton. BRITISH COLUMBIA: Atlin; Blue Lake west of Lytton; Chilcotin; Ft. St. John; Kamloops; Rolla. CALIFORNIA: Black Creek, Modoc Co.; Fallen Leaf Lake, L. Tahoe; King's R. Cyn, Fresno Co.; Gold Lake, Sierra Co.; Rea Lake, Fresno Co., 10500 ft.; Mono Co., 9700 ft.; Mono Lake; Mt. Tallac; Tahoe; Summit of Sonoro Pass;

Summit; Tahoe; Yosemite. COLORADO: Science Lodge near Boulder; Aspen; Boulder; Creede; Dumont; Durango; Electra Lake; Fairplay; Geneva Park Gothic Grand Mesa; Green Mts. Falls; Leadville; Long's Peak, 9000 ft.; Platte; Poncha Springs; South Fork Rio Grande; Rocky Mt. National Park; Silverton; Tennessee Pass; Westcliff. MONTANA: Copperopolis; Gallatin Co.; Missoula; Yellowstone Park. NEVADA: "Nevada". NEW MEXICO: Jebez Mts.; Top of Las Vegas Range, 11000 ft. OREGON: many localities in Steens Mts., Harney Co. UTAH: Beaver Range Mts.; Navajo Lake; North Fork Duchesne River; Uinta National Forest. WYOMING: Big Horn Mts.; Bridger Basin; Jackson; Buffalo; Powder River Pass, 9000 ft.; Medicine Box Range; Yellowstone. YUKON TERRITORY: Whitehorse. Specimens collected from May 20 until September, the majority in July. Specimens in USNM, CAS, CN, AES, AMNH, MCZ, MU, KU, CU, C, FC, MSC, MONT, OR, UCLA, TOW.

Remarks.—*C. robustus* has often been mistaken for *altonii* because of its black abdomen and reddish legs beyond trochanters. *Robustus* always has black or brownish pubescence, the females have the first flageller segment subequal to the second and third segments together, longer malar space, swollen hind femur with apical constriction and ventral ridge, and bilobed anterior tarsal segments; males have normal parameres. *Altonii* has whitish pubescence, first flagellar segment not so long as second and third segments together, normal hind femur and anterior tarsi; the male has a huge paramere with a distinct angulation and tiny, tooth-like pad on apical margin. In size *robustus* varies from 8-18 mm. The abdomen and scape vary from black to reddish-ferruginous. The expansion and spinosity of the tarsal segments in the female is subject to great variation.

CRYPTUS DIRUS Cresson

Fig. 63

Cryptus dirus Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 359, female.
Cryptus violaceipennis Ashmead, 1890, Proc. U. S. Nat. Mus., **12**:408, female (not Brulle 1846). New synonymy.
Cryptus nitschei Dalla Torre, 1902, Cat. Hym., **3**, pt. 2: 581. (New name for *violaceipennis* Ashmead, not Brulle). New synonymy.

Female.—Length 10 mm., ovipositor 4 mm.

Head subpolished with short, blackish pubescence; gena subpolished and punctate, slightly convexly narrowed behind eyes, twice as long opposite malar space as opposite dorsal margin of eye; postocellar line subequal to ocell-ocular line, ocell-ocular line 1.5 times as long as diameter of lateral ocellus; occiput deeply concave; vertex rather densely punctate; frons deeply excavated, rugulose, with a slight vertical ridge behind each antennal foramen; face twice as wide as high, with a strong median elevation; clypeus strongly convex, with narrow, highly polished, slightly reflexed margin; malar space 1.5 times longer than basal width of mandible; mandible twice as long as basal width; occipital carina joining hypostomal about basal width of mandible from mandible; antenna about as long as body, broken in type, but 48-segmented in many specimens, first flagellar segment 5 times as long as wide, second segment 0.7 as long as first, third 0.5 as long as first, following segments successively shorter and narrower.

Pronotum more or less reticulately rugulose, epomia indicated; mesoscutum densely punctate; notaulices strong, slightly foveolate, extending posteriorly as

far as a line opposite posterior margin of tegulae; scutellar fovea longitudinally rugose; scutellum polished, densely but finely punctate; prepectoral carina strong, curving anteriorly and ending 0.7 distance to subalar tubercle; sternaulus deep and complete, subfoveolate; mesopleura, metapleura, and propodeum reticulately rugulose; propodeum with basal transverse carina indicated in middle, apical transverse carina strong; propodeal spiracle 3 times as long as wide.

Legs long, moderately stout, hind coxae polished, sparsely punctate below, finely and densely punctate above, with sparse, short, brownish hairs; hind femur 5 times as long as high; hind tibia 1.2 times longer than hind femur, longer spur 0.4 as long as first segment of hind tarsus; anterior and middle femora swollen, especially anterior femora; second, third, and fourth segments of anterior tarsus moderately expanded; claw pectinate at base, with one large terminal tooth in pecten.

Areolet in fore-wing large, anteriorly convergent, first intercubitus slightly reclivous, second intercubitus inclivous, anterior side longer than either abscissae of cubitus; second recurrent vein simply arched, received slightly beyond middle of areolet; ramellus distinct.

Abdomen robust, coriaceous, subpolished; petiole flattened, dorsally and ventrally, transversely rugose laterally, postpetiole 3 times as wide as petiole; second tergite with posterior margin 1.5 times as wide as basal margin, posterior margin 1.3 times as wide as length of tergite; third tergite almost twice as wide as long; following tergites successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-4.

Black; abdomen reddish; first tergite black; legs black, with anterior legs beyond trochanters, and more or less of tarsi piceous; dot opposite top of eye, and narrow lines on posterior orbits yellowish-white.

Male.—Differs from previous description of female as follows: malar space 0.8 as long as basal width of mandible; flagellum 41-segmented, tarsi simple; claw smaller and pecten with all teeth subequal; postpetiole twice as wide as petiole; abdomen more slender than in female, second tergite almost twice as wide on posterior margin as on basal margin, as long as width of posterior margin; subgenital plate and genitalia (fig. 63).

Lectotype.—Female, California, No. 1134, Academy of Natural Sciences, Philadelphia, Pa.

Male.—Kamloops, British Columbia, June 1, 1938, G. S. Walley, Canadian National Collection, Ottawa, Canada.

The type of *violaceipennis* Ashmead is No. 2020, U. S. National Museum, Washington, D. C.

Distribution.—ARIZONA: Grand Canyon, Haith Springs, Oak Creek Canyon, Kaibab, San Francisco Mts.; CALIFORNIA: Palmdale, Rosamund; BRITISH COLUMBIA: Chilcotin, Kamloops, Keremeos, Pavillon Lake, Princeton Summit; COLORADO: Berkeley, Durango, Manitou, Meeker, Paeonia in Delta Co., Ramosa, Rico, Red Rock, Rifle, South Glade Park, Morrison in Turkey County; IDAHO: Bear Lake, Giveout, Paris; MONTANA: Helena, Laurel; NEVADA: Wells, Ansel Creek, Charleston Mt. Park, Reno; NEW MEXICO: Almogordo, Jemez Springs, Magdalena Mts.; UTAH: Beaver Canyon, South Creek in Beaver County, Eureka, Stockton, Mt. Tampanagos, Wildcat Valley in

Beaver County; WASHINGTON: Dry Coulee in Adrian, Easton, Kennewiek, N. Yakima, Wawawai; WYOMING: Rawlins. Specimens collected in May, June, and July. Some were reared from *Aegeria tibialis* Harris. Specimens in USNM, AES, CN, MU, UCLA, TOW, KU, AMNH, C, CAS, MSC, CU, WASH.

Remarks.—The dark pubescence of *dirus* makes it very distinct in the group of species with black body and reddish abdomen. The female has expanded anterior tarsal segments, and the male has the facial markings reduced to narrow orbital lines, rarely with small spots on face and clypeus. The type of *dirus* represents the small extreme of the species with very slightly expanded anterior tarsi in the female; the type of *violaceipennis* is typical of the majority of specimens in size (14 mm.) and in the broadly expanded anterior tarsal segments in the female. In many specimens the pleura are irregularly diagonally rugulose above middle and hind coxae; the anterior orbits are black in the type of *dirus* but narrowly yellowish in many specimens; size varies from 10-20 mm.

CRYPTUS RELATIVUS Cresson

Fig. 40, 64

Cryptus relativus Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 359, female; Criddle, 1928, 58th Ann. Rept. Ent. Soc. Ont.: 103.

Cryptus pictifrons Cresson, 1878, Proc. Acad. Nat. Sci. Phil.: 360, male. New synonymy.

Female.—Length 13 mm., ovipositor 4 mm.

Head densely clothed with short, somewhat appressed, silvery-white pubescence; genae subpolished, densely but finely punctate, sharply and very slightly convexly narrowed behind eyes, much longer near mandible than dorsally; occiput deeply concave; vertex granularly punctate; postocellar line subequal to ocell-ocular line, distinctly longer than diameter of lateral ocellus; eyes parallel; frons deeply excavated, with slight vertical ridge behind each antennal foramen; face twice as wide as high, with a median elevation; clypeus convex, with a thin, highly polished, reflexed margin; labrum projecting, arcuate; malar space 1.5 times as long as basal width of mandible; mandible about twice as long as basal width; antenna long and slender, 0.7 as long as body, flagellum 49-segmented, first segment 5.5 times as long as wide, not quite as long as second and third segments together, second 0.7 as long as first, following segments successively shorter.

Pronotum rugulose, almost striately so along posterior-lateral margin, epomia weak; mesoscutum densely punctate, confluently so in median area enclosed by notaulices; notaulices strongly impressed to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally rugose; scutellum highly polished, very finely punctate; prepectoral carina incomplete extending 0.7 distance to subalar tubercle; sternaulus complete, broadly and deeply impressed at base, subfoveolate; mesopleura and propodeum reticulate rugulose, more finely so dorsally, more coarsely ventrally; metapleura rather obliquely rugulose; speculum polished, very finely punctate; propodeum with a trace of basal transverse carina, apical transverse carina present, strongest on lateral angles; propodeal spiracle elongate, slit-like, 3 times as long as wide.

Legs rather long and slender, all coxae subpolished, sparsely punctate, hind femur 5 times as long as high, hind tibia 1.2 times longer than hind femur, longer spur of hind tibia 0.4 as long as first segment of hind tarsus; four anterior tarsi with segments symmetrically expanded and spinose, longer spines about as long as median length of segments; claw large, as long as median length of segments three of anterior tarsus, pectinate at base, pecten ending in one, large, terminal tooth.

Areolet moderately large, convergent anteriorly, first intercubitus slightly reclivous, second intercubitus slightly inclivous, anterior side longer than either abscissa of cubitus; second recurrent vein simply arched, received about in middle of areolet; ramellus distinct.

Abdomen robust, finely coriaceous; petiole polished, depressed, weakly transversely rugose laterally, dorsal carinae strong, postpetiole slightly more than 3 times as broad as petiole; second tergite 1.7 times as wide at posterior margin as long; third tergite 1.8 times as wide as long; following tergites transverse, successively shorter and narrower; ovipositor scimitar-shaped, sheaths of ovipositor as long as tergites 2-5.

Black; abdomen beyond petiole, all femora, and more or less of fore and middle tibiae and tarsi reddish-ferruginous; anterior and middle tibiae and tarsi slightly darker than femora; hind tibia and tarsus black or rufo-piceous; short lines on anterior and posterior orbits, dot opposite top of eye, yellowish-white; wings uniformly and dilutely infumate, stigma and veins dark piceous.

Male.—Differs from preceding description of female as follows: pubescence longer and more abundant on head; mandible twice as long as basal width of mandible; gena about as long dorsally as opposite malar space; malar space subequal to basal width of mandible; flagellum 43-segmented, segments subcylindrical; pronotum more finely sculptured; mesoscutum more densely punctate; mesopleura, metapleura, and propodeum less strongly rugulose; propodeum with apical transverse carina weak, straight across middle of propodeum; basal transverse carina much stronger; tarsi normal; abdomen more slender; male subgenital plate and genitalia (fig. 64); subgenital plate very wide and short.

Black; abdomen beyond spiracles of first tergite, all femora, and more or less of fore and middle tibiae and tarsi, reddish-ferruginous; narrow lines on posterior orbits, broad anterior orbits, line opposite top of eye, median spot on clypeus, labrum, and second segment of maxillary palpus, segments 2-4 of hind tarsi yellowish-white; hind tibia and first segment of hind tarsus black.

Lectotype.—Female, British Columbia, No. 1155, Academy of Natural Sciences, Philadelphia, Pa.

Allotype.—Male. The allotype is the lectotype of *pictifrons* Cresson, Green River, Wyoming, No. 1149, Academy of Natural Sciences, Philadelphia, Pa.

Distribution.—ALBERTA: Banff, Calgary, Nordogg, Waterton; BRITISH COLUMBIA: Agassiz, Aspen Grove, Chilcotin, Copper Mt., Hope Summit, Keremeos, Lytton, Mt. McLean, Nicola Lake, Nicola, Okanaga, Pavillon Lake, Peachland, Fort St. John, Skagi Valley, Williams Lake; CALIFORNIA: Fallen Leaf Lake, El Dorado Co., Gold Lake in Sierra Co., King's R. Cyn in Fresno Co., Lake Tahoe; COLORADO: Aspen, Berkeley, Boulder, Cornet Creek in Tellurida, Delta, Electra Lake, Florissant, Fort

Collins, Garfield, Rocky Mt. Park, Green Mt. Falls, Jim Creek near Boulder, Lake City, Leadville, Red Rock Peak, Mill Gulch, Rockwood, Plainview in Jefferson County, Poudre Canyon, Salida, Argent, Starkville, Virginia Dale; IDAHO: Bear Lake, Freemont, Giveout, Montpelier, Victor, Wallace, Warren; MONTANA: Bozeman, Bridge Mts., Crazy Mts., East Shore of Flathead Lake, Gallatin Co., Helena, Missoula, Kalispell, Park Co., Ravalli Co.; NEVADA: Wells, Reno; NEW MEXICO: Almogordo, Jemez Springs; OREGON: Crater Lake, Dixie Butte Spring in Grant Co., Steens Mts., Klamath Falls, Lick Creek in R. S. Wallowa National Forest, Wallowa Mts. in Baker Co.; UTAH: Aspen Grove, Ft. Duchesne, Grantsville, Logan, Heber, Navajo Lake, Park County, South Creek in Beaver Co., Strawberry Valley, Trout Creek, Mt. Timpanegos, Uinta National Forest, West Jordan; WASHINGTON: Blue Mts., N. Yakima, Hell's Crossing, Forest Camp in Yakima County, Pullman, Tucanon in R. S. Blue Mt. Ranier National Park; WYOMING: Mt. Adams, Bridger Basin, Green River, Jackson, Shoshone Canyon. Some were reared from *Aegeria tibialis* Harris. On the wing from May through August. Specimens in AES, USNM, CN, BC, MU, TOW, CAS, AMNH, C, FC, MSC, KU, BS, MONT, CU, OR, UTAH, UCLA, W.

Remarks.—The number of flagellar segments varies from about 50 in the female to as low as 40 in the male; the mesopleura and metapleura of the type are not so strongly rugulose as in many other specimens; the mesopleura and metapleura are often obliquely rugose above the middle and hind coxal cavities. There is considerable variation in the length and number of spines on the anterior and middle tarsi in the female. The most distinctive feature of the male genitalia appears to be the very broad and short subgenital plate.

Cryptus mimicus, new species

Figs. 65, 75

Female.—13 mm.; ovipositor 6 mm.

Head coriaceous, with short, somewhat silvery-white pubescence; genae subpolished, densely and finely punctate, strongly and convexly narrowed behind eyes, in lateral view much shorter anteroposteriorly than length of eye and about as wide opposite dorsal as ventral margin of eye; postocellar line subequal to ocell-ocular line, 1.3 times as long as diameter of lateral ocellus; occiput shallowly concave; frons deeply excavated, coriaceous above, subpolished and with a vertical ridge behind each antennal foramen; face 2.2 times as wide as high, with prominent, median elevation; clypeus gibbous, with a thin, slightly reflexed apical margin; malar space equal to basal width of mandible; mandible 1.7 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 43-segmented, first flagellar segment 4.5 times as long as wide, second 0.7 as long as first, following segments successively shorter and narrower.

Pronotum with distinct epomia; mesoscutum densely punctate, notaulices strong, extending posteriorly as far as a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum densely punctate, especially posteriorly; prepectoral carina complete, attaining subalar tubercle; sternaulus complete, deeply and broadly impressed, subfoveolate; mesopleura, metapleura, and propodeum reticulate-rugulose, slightly obliquely so on mesopleura and metapleura; speculum highly polished, with few scattered punctures; propodeum with a small triangular basal area, both basal and apical

transverse carinae present, basal carina V-shaped in middle; apical carina slightly produced laterally; propodeal spiracle 3.5 times as long as wide.

Coxae densely punctate and clothed with short, appressed, silvery-white pubescence; hind femur 5 times as long as high; hind tibia 1.2 times as long as hind femur, longer spur of hind tibia 0.3 as long as first segment of hind tarsus; tarsi normal, not expanded; claw large, pectinate at base, with one large, terminal tooth in pecten.

Areolet slightly convergent anteriorly, first intercubitus reclivous, second intercubitus perpendicular, anterior side subequal to either abscissa of cubitus; second recurrent vein simply arched, received slightly beyond middle of areolet.

Abdomen finely coriaceous; petiole depressed, slightly transversely rugulose laterally, postpetiole 3 times as broad as petiole; second tergite 1.5 times as broad on posterior margin as long; third tergite about twice as broad as long; following tergites transverse successively shorter and narrower; ovipositor sagittate, sheaths about as long as tergites 2-5.

Black; narrow lines on facial and posterior orbits and dot opposite top of eye, yellowish-white; abdomen, except basal 0.7 of first tergite, apical segment of all trochanters, and all femora reddish-ferruginous; anterior and middle tibiae and tarsi rufo-piceous; hind tibia and first segment of hind tarsus fuscous; segments 2-4 of hind tarsus yellowish-white, apical segments brown; scape ferruginous beneath, rest of antenna black; apices of flagellar segments narrowly piceous.

Male.—11 mm. Differs from preceding description of female as follows: face 1.6 times as wide as high, mandible 1.5 times as long as basal width of mandible, malar space 0.8 as long as basal width of mandible; vertical ridge behind each antennal foramen stronger than in female; flagellum 38-segmented; epomia weaker, pleura more finely punctate; propodeum more evenly convex from base to apex; propodeal spiracle 3 times as long as wide; abdomen much more slender; first terigte with postpetiole twice as wide as petiole, sternite extending well beyond spiracle; second tergite 3 times as long as basal width; following tergites successively shorter; subgenital plate and male genitalia (fig. 65).

Black; hind femora and abdomen beyond first tergite reddish-ferruginous; anterior and middle femora, tibiae, and tarsi more or less rufo-piceous, the femora more ferruginous, tarsi more piceous; hind tibia and first segment of hind tarsus fuscous with a piceous line anteriorly; narrow lines on posterior orbits, line opposite top of eye, broad anterior orbits, spots on clypeus, spot on mandible, small spots on anterior coxa and trochanter, second segment of maxillary palpus, anterior half of tegula, subalar tubercle, segments 2-4 of hind tarsus, yellowish-white.

Holotype.—Female, Jemez Springs, New Mexico, July 24, 1929, G. P. Engelhardt, Cat. No. 55428, U. S. National Museum, Washington, D. C.

Allotype.—Male, Boulder County, Colorado, June 18-July 19, 1933, 9500 ft., J. C. Jones, University of Minnesota, St. Paul, Minn.

Paratypes.—ALBERTA: Banff, Raley; BRITISH COLUMBIA: Creston, Glenora, Hope Mt., Pavillon Lake, Vernon; COLORADO: Science Lodge near Boulder, Fort Collins;

MONTANA: Big Horn County, East Shore of Flat Head Lake, Park County, Sheridan; OREGON: Corvallis, Grant County, Klamath Falls; UTAH: Beaver Creek Hills in Beaver County, Cedar City, Ft. Duchesne, Vivian Park, West Jordan. Specimens collected in the field from middle May until August. Specimens in USNM, AES, CN, MU, C, CU, MONT, CAS, UTAH.

Remarks.—The strongly narrowed genae are characteristic of *mimicus* and *temporalis*. The very slightly expanded anterior tarsi in the female, and the longer, narrower subgenital plate should aid in separating this species from *relativus* Cresson. Both sexes of *mimicus* have the mesoscutum and coxae more densely and finely punctate than in *relativus*. In size *mimicus* varies from 10-15 mm. Females may have the scape black or entirely reddish. In the male the tegulae vary from entirely white to entirely black, but usually are black with the anterior half white; the clypeus may have a median white spot; the anterior and middle femora are often as ferruginous as hind femora, and the postpetiole may be fuscous or reddish-ferruginous; flagellum 38-44-segmented.

Cryptus temporalis, new species

Fig. 66

Female.—Length 13 mm., ovipositor 4.5 mm.

Head clothed with very short, somewhat appressed pubescence; genae densely punctate and subpolished, strongly obliquely narrowed behind eyes, nearly flat, not as long antero-posteriorly as eye and as wide dorsally as ventrally; ocell-ocular line subequal to post-ocellar line, 1.3 times as long as diameter of lateral ocellus; occiput deeply concave; vertex densely punctate; frons deeply excavated and rugulose, with a strong ridge behind each antennal foramen; face twice as wide as high, coriaceous, with a strong, median elevation; clypeus strongly elevated basally, broadly depressed apically with a highly polished, slightly reflexed apical margin; labrum projecting; malar space shagreened, 1.3 times longer than basal width of mandible; mandible 1.7 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 45-segmented, first flagellar segment 5 times as long as wide, second 0.6 as long as first, third 0.5 as long as first.

Pronotum finely rugulose dorsally, coarsely rugulose ventrally, with weak irregular epomia; mesoscutum finely and densely punctate; notaulices strongly impressed, subfoveolate, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum more strongly punctate than mesoscutum; prepectoral carina strong, attaining subalar tubercle; mesopleura, metapleura, and propodeum strongly and irregularly rugulose; speculum elevated, smooth and polished; propodeal carinae similar to *mimicus*, basal carina weak, apical transverse carina strong; propodeal spiracle elongate, 3 times as long as wide.

Areolet large, first intercubitus slightly reclivous, second intercubitus strongly inclivous, anterior side 0.7 as long as first intercubitus; second recurrent vein simply arched, received about in middle of areolet; ramellus strong, nervulus antefurcal.

Hind coxa densely and confluently punctate; hind femur 5 times as long as high; hind tibia 1.2 times as long as hind femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tarsi slightly expanded; claw pectinate, pecten ending in one, large, terminal tooth.

Abdomen finely coriaceous; petiole depressed, transversely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carina fading out slightly beyond spiracles; second tergite 1.5 times as wide as long, apex twice as wide as base; third tergite nearly twice as wide as long; following tergites transverse, successively shorter and narrower; ovipositor scimitar-shaped with about 10 minute ventral teeth; sheaths of ovipositor lost in holotype, but as long as tergites 2-4 in paratypes.

Black; abdomen except for most of first tergite, reddish; labrum, line on facial and posterior orbits and dot opposite top of eye, yellowish-white; wings pale fuscous, veins and stigma black; four anterior tibiae and tarsi piceous; hind tarsi with segments 2-4 yellowish-white.

Male.—Length 13 mm. Differs from preceding description of females as follows: malar space 0.8 as long as basal width of mandible, flagellum 43-segmented; pronotum punctate dorsally, finely rugulose ventrally, pleura reticulately rugulose-punctate; propodeum more evenly convex from base to apex, basal transverse carina stronger than apical; postpetiole twice as broad as petiole; second tergite 3 times as long as basal width; subgenital plate and genitalia (fig. 66).

Black; abdomen beyond first tergite reddish-ferruginous; narrow lines on posterior orbits, broad anterior orbits, most of malar space, spot on face, clypeus, most of mandible, second segment of maxillary palpus externally, spot on anterior coxa and trochanter, spot on subalar tubercle, segments 2-4 of hind tarsus, white; anterior and middle femora, tibiae, and tarsi various shades of rufo-piceous, darkest on tips of tibiae and first segment of tarsi.

Holotype.—Female, Boulder, Colorado, Cockerell, Cat. No. 55429, U. S. National Museum, Washington, D. C.

Allotype.—Male, Pullman, Washington, June 10, 1898, in U. S. National Museum, Washington, D. C.

Paratypes.—ALBERTA: Banff; ARIZONA: Jerome; So. Angel Trail in Grand Canyon; BRITISH COLUMBIA: Chilcotin; Lilooet; Nicola; Pavillon Lake; Salmon Arm; COLORADO: Boulder; Durango; Gothic; Red Rocks; Rio Grande County; MONTANA: Bozeman; East shore of Flat Head Lake; Helena; NEW MEXIICO: Jemez Springs; Santa Fe; UTAH: Logan; Zion Park; WASHINGTON: Almota; Pullman; Wawawai. Collections made from May until middle part of August. Specimens in USNM, CN, CU, BC, AMNH, MSC, C, AES, FC, MU, MONT, UTAH, WASH.

Remarks.—Superficially very close to *dirus* Cresson in general color pattern, but quite distinct in pale pubescence, strongly narrowed genae, white-spotted tegulae in male, and normal anterior tarsi in female. The black hind femur appears to be the only constant character to separate this species from *mimicus*.

Cryptus latigenalis, new species

Fig. 41

Female.—Length 7 mm.; ovipositor 2 mm.

Head with sparse, silvery-white pubescence; genae broad, in lateral view as wide dorsally as ventrally, slightly narrowed behind eyes, nearly flat; ocell-ocular line 1.5 times as long as diameter of lateral ocellus, 1.2 times longer than post-ocellar line; occiput deeply concave; vertex coriaceous, ocellar triangle rugulose; frons slightly excavated, densely punctate above, coriaceous in middle, smooth and polished, entirely without vertical ridge behind each antennal foramen; face twice as wide as high, with a median elevation; clypeus moderately convex, with a thin, slightly reflexed apical margin; mandible 1.7 times as long as basal width of mandible; malar space 1.3 times as long as basal width of mandible; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 31-segmented, basal flagellar segment 6 times as long as wide, second segment 0.8 and third segment 0.6 as long as first segment.

Pronotum punctate-rugulose, with sharp epomia; mesoscutum shining, densely punctate; notaulices foveolate, extending posteriorly to a line tangential to posterior margin of tegula; scutellar fovea longitudinally striate; scutellum convex, polished, sparsely punctate; prepectoral carina incomplete, extending 0.6 distance to subalar tubercle; speculum slightly elevated, as densely punctate as mesopleurum; mesopleura, metapleura, and propodeum densely puncate-rugulose; propodeum short, 0.7 as long as broad; apical transverse carina strong and complete, basal transverse carina weak and incomplete, strongest medially; propodeal spiracle twice as long as wide.

Coxae polished, densely punctate; hind femur 6 times as long as high; hind tibia 1.2 times as long as femur, longer spur 0.5 as long as first segment of hind tarsus; tarsi normal, claw small, without a large terminal tooth in pecten.

Areolet strongly convergent anteriorly, first intercubitus strongly reclivous, second intercubitus strongly inclivous, anterior side 0.3 as long as first intercubitus; second recurrent vein simply arched, received in middle of areolet; nervulus interstitial; ramellus present.

Abdomen finely coriaceous, except petiole of first tergite which is depressed and subpolished dorsally and ventrally, and coarsely punctate laterally, postpetiole 3.5 times as wide as petiole, dorsal carinae present, fading out opposite spiracles; second tergite as long as wide at base, posterior margin 1.4 times as wide as basal margin; third tergite almost twice as wide as long, wider at base than at posterior margin; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-4.

Black; abdomen, except bast of first tergite, reddish-ferruginous; pale lines opposite top of eyes, and on anterior and posterior orbits; wings hyaline, suffused with fuscous; stigma and veins piceous.

Holotype.—Female, Hidden Valley, Rocky Mountain National Park,

Colorado, June 27, 1933, Helen Rodeck, Cat. No. 55439, U. S. National Museum, Washington, D. C.

Male unknown.

Paratypes.—1 female, Cripple Creek, Colorado, July 29, S. A. Rohwer (MU); 1 female, Colorado, 1234, C. F. Baker (USNM).

Remarks.—Superficially similar to *dirus* Cresson but easily separated on smaller size, few flagellar segments, broad genae, short propodeal spiracle, and whitish pubescence; from *albitarsis* (Cresson) easily distinguished by the simply arched, second recurrent vein.

Cryptus inornatus, new species

Fig. 42

Female.—Length 8 mm., ovipositor 2 mm.

Head with short, sparse, somewhat appressed silvery-white pubescence; genae subpolished, sparsely and finely punctate, strong-convexly narrowed behind eyes, narrower dorsally than ventrally; postocellar line 1.5 times as long as diameter of lateral ocellus; ocell-ocular line 1.1 times as long as diameter of lateral ocellus; occiput shallowly concave; vertex subpolished, finely punctate, more strongly punctate in ocellar triangle; frons shallowly excavated without a vertical ridge behind antennal foramen; face twice as wide, with a median elevation; clypeus convex with a polished, slightly reflexed apical margin; malar space subequal to basal width of mandible; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 35-segmented, first flagellar segment 5 times as long as wide, second segment shorter, third 0.5 as long as first.

Pronotum punctate dorsally, rugulose ventrally, with weak epomia; mesoscutum polished, densely punctate; notaulices strongly impressed, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally rugose; scutellum polished and finely punctate; prepectoral carina complete, attaining subalar tubercle; sternaulus complete; mesopleura, metapleura, and propodeum coarsely and confluently punctate; speculum slightly elevated, polished, sparsely and finely punctate; propodeum with basal transverse carina present and complete; apical carina indicated in middle, stronger on lateral angles; propodeal spiracle twice as long as wide.

Areolet strongly anteriorly convergent, first intercubitus strongly reclivous, second intercubitus strongly inclivous, anterior side shorter than either abscissa of cubitus; second recurrent vein simply arched, received beyond middle of areolet; ramellus absent.

Legs with coxae polished, finely and densely punctate; hind femur 5 times as long as high; hind tibia 1.2 times as long as femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; tarsus simple; claw small, simply pectinate at base, without a large terminal tooth in pecten.

Abdomen coriaceous; petiole polished, depressed, transversely rugulose laterally, dorsal carinae present, but not strong, postpetiole polished, 3 times

as wide as petiole; second tergite 1.5 times as wide at posterior margin as at basal margin; third tergite twice as wide as long; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths broken in type, but as long as tergites 2-4 in paratypes and apparently of same length in holotype.

Black; abdomen reddish-ferruginous; tibiae and tarsi slightly piceous; narrow lines on anterior and posterior orbits yellowish-white; wings dilutely and uniformly infumate, stigma and veins dilutely infumate.

Holotype, Bozeman, Montana, 4800 ft., July 22, 1901, E. J. S. Moore, Cat, No. 55431 U. S. National Museum, Washington, D. C.

Paratypes.—1 female, Montana Experiment Station, Dillon, Montana, July 8, 1913 (MONT); 1 female, Lethbridge, Alberta, June 20, 1938, R. W. Salt (TOW).

Remarks.—The holotype lacks the ramellus, but it is present in the paratypes. *Inornatus* is similar to *albitarsis* (Cresson) in general color, but apparently distinct in simply arched second recurrent vein, and in several characters of the head.

Cryptus dorsicarinatus, new species

Fig. 67

Female.—Length 9 mm., ovipositor 4 mm.

Head with short, sparse, somewhat appressed silvery-white pubescence; genae subpolished, sparsely and finely punctate, slightly, rather convexly narrowed behind eye, narrower dorsally than ventrally; postocellar line 1.1 times as long as ocell-ocular line and lateral ocellus; occiput moderately concave; vertex coriaceous; frons deeply excavated with a strong, vertical ridge behind each antennal foramen; face twice as wide as high, with strong, median elevation; clypeus convex with polished, slightly reflexed apical margin; malar space 1.2 times as long as basal width of mandible; mandible 1.5 times as long as basal width; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 37-segmented, first segment 5.5 times as long as wide, second segment 0.8 as long as first.

Pronotum densely and coarsely punctate, with weak epomia; mesoscutum subpolished, densely punctate; notaulices strongly impressed, extending posteriorly to a line drawn tangential to posterior margins of tegulae; scutellar fovea longitudinally rugose; scutellum convex, finely punctate; prepectoral carina complete, extending to subalar tubercle; sternaulus complete, but weak; mesopleura, metapleura, and propodeum coarsely and confluently punctate; speculum slightly elevated, polished, impunctate; basal transverse carina indicated, posterior transverse carina strong, slightly produced on lateral angles; propodeal spiracle about twice as long as wide.

Areolet strongly anteriorly convergent, first intercubitus strongly reclivous, second intercubitus strongly inclivous, anterior side as long as first abscissa of cubitus; second recurrent vein gently arched, received slightly before middle of areolet; ramellus present.

Legs rather slender, coxae densely punctate; hind femur 5 times as long as wide, hind tibia 1.2 times as long as first segment of hind tarsus; anterior tarsus simple; claw simply pectinate at base, without large terminal tooth in pecten.

Abdomen coriaceous; petiole polished, flattened dorsally and ventrally, transversely rugose laterally, dorsal carina very prominent, area between carina somewhat longitudinally grooved, postpetiole coriaceous, 3 times as wide as petiole; second tergite about as long as basal width, posterior margin 1.5 times as wide as basal margin; third tergite shorter than second, about twice as wide as long; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths broken in holotype, but in paratypes as long as tergites 2-4.

Black; legs beyond trochanters and abdomen, except base of first tergite, reddish-ferruginous; all tarsi and hind tibiae infuscated; narrow lines on anterior and posterior orbits, yellowish-white; wings uniformly and dilutely infumate, veins and stigma piceous.

Male.—Length 8 mm.

Differs from preceding description of female as follows: postocellar line 1.2 times as long as ocell-ocular line, ocell-ocular line subequal to diameter of lateral ocellus; face 1.7 times as wide as high; mandible 1.5 times as long as basal width; malar space 0.8 as long as basal width of mandible; flagellum 37-segmented, basal segment 3 times as long as wide; pleura not so coarsely punctate; propodeum sloping more evenly from base to apex, basal transverse carina stronger than apical, basal carina complete, apical carina merely indicated; areolet very strongly convergent, second intercubitus strongly inclivous, second recurrent vein received distinctly before middle of areolet; abdomen more slender and first tergite without dorsal carinae, with a distinct pit or depression at base of postpetiole.

Black; abdomen, beyond first tergite, and all femora reddish; anterior and middle tibiae and tarsi pale ferruginous; hind tibiae, base of first segment of hind tarsus, and fifth segment of hind tarsus black; distal half of first segment and segments 2-4 of hind tarsus, spots on anterior and middle coxae and trochanters, subalar tubercle, spot on tegula, broad anterior orbits to top of eye, narrow posterior orbits interrupted dorsally and ventrally, V-shaped mark on face, clypeus, labrum, most of mandible, and scape ventrally yellowish-white.

Holotype.—Female, Vancouver, British Columbia, August 31, 1904, also bears a label 1230, typewritten in purple ink, Cat. No. 55437, U. S. National Museum, Washington, D. C.

Allotype.—Male, Navajo Lake, Utah, 9000 feet, June 17, 1940, R. M. Bohart, in California Academy of Sciences, San Francisco, California.

Paratypes.—BRITISH COLUMBIA: Ground Hog Basin to Downie Creek in Selkirk Mts.; Hedley; Keremeos; Kokanee Mts. collected on snow; Revelstoke Mt.; Rogers Pass; Vancouver; Victoria; CALIFORNIA: Alpine Creek; Tahoe; IDAHO: Lake Waha; UTAH: Navajo Lake, 9000 ft.; WASHINTON: Longmires; Ranier National Park. Specimens collected in May, June, July, and August. Specimens in USNM, CAS, CU, MU, CN, UCLA.

Remarks.—C. *dorsicarinatus* is a very distinct, small species which should

not be confused with other *Cryptus* because of its simply arched second recurrent vein, strong vertical ridge behind each antennal foramen, convergent areolet, and strong dorsal carinae on petiole. The male is easily distinguished by the strongly convergent areolet and the form of the male genitalia (fig. 67).

Cryptus rugulosus, new species

Female.—Length 7 mm., ovipositor 3 mm.

Head coriaceous, subpolished, with short, silvery-white pubescence; gena distinctly, convexly narrowed behind eye; occiput broadly concave; vertex granularly punctate, more coarsely punctate in ocellar triangle; postocellar line subequal to ocell-ocular line, 1.2 times as long as diameter of lateral ocellus; frons moderately excavated, finely rugulose dorsally, more polished and entirely without a ridge behind each antennal foramen; face 2.1 times as wide as high, with a median elevation; clypeus strongly elevated at base and abruptly depressed beyond middle, subnasutiform; malar space equal to basal width of mandible; mandible 1.5 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna broken in type, fragment 15-segmented, basal flagellar segment 4.5 times as long as wide, second 0.7 and third 0.6 as long as first.

Pronotum punctate dorsally, rugulose ventrally, epomia present but not strong; mesoscutum subpolished, finely but densely punctate; notaulices sharply impressed, extending posteriorly as far as line tangential to posterior margins of tegulae; scutellum slightly convex, as punctate as mesoscutum; prepectoral carina extending 0.8 distance to subalar tubercle; sternaulus complete, subfoveolate; mesopleura, metapleura, and propodeum coarsely and irregularly rugulose, almost diagonally so posterior to prepectoral carina; speculum elevated, polished, impunctate; propodeum with only posterior transverse carina present, strong laterally, weak in middle; posterior face of propodeum 1.5 times as long as dorsal face; propodeal spiracle 3 times as long as wide.

Areolet broad, intercubiti subparallel; first intercubitus slightly reclivous, second intercubitus perpendicular, anterior side of areolet as long as second abscissa of cubitus; second recurent vein simply arched, received slightly before middle of areolet.

Legs moderately short and stout; coxae polished and punctate; hind femur 4 times as long as high; hind tibia 1.3 times as long as femur, longer spur of hind tibia 0.3 as long as first segment of hind tarsus; anterior tibia increasing in diameter gradually from base to tip; tarsi simple, but with many spines ventrally; claw small, as long as fourth segment of hind tarsus, finely pectinate at base, with one large, terminal tooth in pecten.

Abdomen coriaceous, posterior segment rather compressed; petiole depressed, dorsal carinae merely indicated, postpetiole 3 times as wide as petiole; second tergite as long as basal width, posterior margin 1.3 times as wide as basal margin; abdomen compressed from second tergite on (probably due to position of ovipositor) so that the following tergites appear from above to be quadrate while actually they are transverse; ovipositor weakly sagittate

with tiny, dorsal notch and very fine ventral teeth; sheath of ovipositor as long as tergites 2-7.

Black; abdomen beyond spiracles of first tergite and all femora reddish-ferruginous; all tibia and tarsi piceous, anterior pair palest; narrow lines on anterior and posterior orbits and opposite top of eye, hind tarsus with segments 2-4, pale yellowish-white.

Holotype.—Female, Banff, Alberta, July 7, 1922, C. B. D. Garrett, in Canadian National Collection, Ottawa, Canada.

Remarks.—Known only from the unique female. Appears allied to the *relativus* group, but ovipositor is shorter, femora stouter, tarsi simple, frons shallowly excavated without vertical ridge behind each antennal foramen. Somewhat allied to *dorsicarinatus* in size and general habitus, but easily distinguished from that species by shape of the areolet, strength of dorsal carinae, and shallowly excavated frons.

Cryptus recurvatus, new species

Female.—Length 10 mm., ovipositor 5 mm.

Head densely clothed with white pubescence; genae finely and densely punctate, sharply and obliquely narrowed behind eyes, nearly flat; ocell-ocular line as long as diameter of lateral ocellus, 0.7 as long as post-ocellar line occiput deeply concave; vertex strongly punctate; frons moderately excavated, punctate above, transversely striate below, entirely without vertical ridge behind each antennal foramen; face twice as wide as high, with a median elevation; clypeus convex, with a thin, slightly reflexed, apical margin; labrum projecting; mandible 1.7 times as long as basal width; malar space 1.3 times as long as basal width of mandible; occipital carina 0.8 basal width of mandible from mandible at point of junction with hypostomal carina; antenna entirely missing.

Pronotum finely, reticulately rugulose, with a weak epomia; mesoscutum densely punctate, notaulices strongly impressed extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally rugose; scutellum rather densely punctate; basal half flattened, apical half gradually receding; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete, deeply impressed, subfoveolate; speculum moderately elevated, subpolished, moderately punctate; mesopleura, metapleura, and propodeum reticulately rugulose-punctate; propodeum with apical, transverse carina strong, basal transverse carina merely indicated; propodeal spiracle 3 times as long as wide.

Coxae finely and densely punctate; hind femur 5.5 times as long as high; hind tibia 1.3 times as long as hind femur; longer spur of hind tibia as long as first segment of hind tarsus; tarsi normal, not expanded; claw small, weakly pectinate at base.

Areolet strongly convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side 0.5 as long as first intercubitus; second recurrent vein simply arched, received beyond middle of areolet; nervulus antefurcal; ramellus present.

Abdomen slender, coriaceous, first tergite polished, long and slender, 2.3 times as long as width of postpetiole, postpetiole 3 times as wide as petiole, dorsal carinae absent; second tergite as long as basal width; third tergite 1.5 times as wide as long; following tergites transverse, successively shorter and narrower; ovipositor very slender, recurved, sagittate, sheaths of ovipositor as long as abdomen.

Black; abdomen and middle and hind femora reddish-ferruginous; anterior femora and all legs beyond femora rufo-piceous; a dot opposite top of eye, narrow lines on anterior and posterior orbits, yellowish-white; wings hyaline; stigma and veins piceous.

Holotype.—Female, Real del Monte, Hidalgo, Mexico, Cat. No. 55424, U. S. National Museum, Washington, D. C.

Paratype.—1 female, San Francisco, Arizona (MU); differs from holotype in having middle femora piceous and all legs with tibia and tarsi more uniformly piceous to dull black.

Remarks.—This species is remarkable in the long, slender petiole without dorsal carinae, in its elongate spiracle, and especially the recurved ovipositor.

Cryptus ocellaris, new species

Fig. 82

Female.—Length 6 mm.; ovipositor 2 mm.

Head very finely punctate, with very short, sparse, silvery-white pubescence; genae short, finely punctate, obliquely narrowed behind eyes, nearly flat; ocell-ocular line subequal to diameter of lateral ocellus, post-ocellar line 1.5 times diameter of lateral ocellus; occiput deeply concave; vertex finely and densely punctate; frons shallowly excavated, granularly punctate, without a vertical ridge behind each antennal foramen; face twice as wide as high; clypeus very convex at base, abruptly depressed beyond middle, margin polished and slightly reflexed; malar space 0.8 as long as basal width of mandible; mandible 1.5 times as long as basal width; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 34-segmented, first segment 6 times as long as wide, second 5 times as long as wide, third 0.5 as long as first.

Pronotum densely punctate, with a weak epomia; mesoscutum finely and densely punctate, notaulices extending posteriorly to a line tangential to posterior margins of tegulae; scutellum finely punctate; prepectoral carina complete, attaining subalar tubercle; sternaulus moderately impressed, complete; speculum slightly elevated, sparsely punctured; mesopleura, metapleura, and propodeum finely, reticulately rugulose-punctate; propodeum with apical transverse carina strong, basal transverse carina weak, dorsal face of propodeum 0.8 as long as petiolar area, propodeum sloping very slightly to apical transverse carina, then abruptly declivous; propodeal spiracle twice as long as wide.

Coxae granularly punctate; hind femur 5 times as long as high; hind tibia 1.3 times as long as hind femur, longer spur of hind tibia 0.4 as long as first segment of hind tarsus; tarsi normal; claws small, weakly pectinate at base, without a large terminal tooth in pecten.

Areolet broadly anteriorly convergent, first intercubitus slightly reclivous, second intercubitus slightly inclivous, anterior side of areolet 0.6 as long as first intercubitus; second recurrent vein simply arched, received slightly beyond middle of areolet; nervulus antefurcal; ramellus present.

Abdomen finely coriaceous, subpolished; petiole very slightly depressed, strongly coriaceous laterally, postpetiole 3.5 times as wide as petiole; dorsal carina slightly indicated; second tergite almost twice as wide at posterior margin as at base, 1.5 times as long as basal width; third tergite 1.5 times as wide as long; following tergites transverse, successively shorter and narrower; ovipositor straight, sagittate, sheaths of ovipositor as long as tergites 2-4.

Black; scape ventrally, and abdomen and legs entirely reddish-ferruginous; eyes completely encircled by yellowish-white orbits except opposite median ocellus and behind top of eyes; lines on posterior-lateral and anterior margins of pronotum, tegulae, dot before and beneath tegulae, yellowish-white; wings hyaline, stigma and veins piceous.

Holotype.—Female, bears a typewritten label "5". This species was taken in a greenhouse in Reno, Nevada, by S. B. Doten in the summer of 1911. The "5" refers to the fact that the specimen lived for 5 days during longevity experiments. Cat. No. 55427 U. S. National Museum, Washington, D. C.

Paratypes.—2 females bearing typewritten labels "5" and "200." These specimens likewise came from Reno, Nevada and were collected by S. B. Doten in the summer of 1911.

Remarks.—This species is very similar in color pattern to *tejonensis*, *rufopedibus*, and the male *pacificus*. It differs from these last three species in uniformly smaller size, shorter and smaller spiracle, fewer flagellar segments, and in the structure of the frons which is not strongly transversely rugulose as in *tejonensis*, nor with a strong, vertical ridge behind each antennal foramen as in *rufopedibus* and in the male of *pacificus*.

Cryptus aridus, new species

Female.—Length 6.5 mm., ovipositor 2 mm.

Differs from preceding description of *ocellaris* as follows: face 1.8 times as wide as high; frons shallowly excavated, punctate dorsally, slightly transversely rugulose behind each antennal foramen; malar space subequal to basal width of mandible; flagellum 33-segmented; pronotum finely rugulose, with weak epomia; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; propodeum with both basal and apical transverse carina strong, dorsal face of propodeum as long as petiolar area; anterior side of areolet 0.5 as long as first intercubitus; second tergite twice as wide at posterior margin as at base, 1.8 times as long as basal width; sheaths of ovipositor as long as tergites 2-3.

Black; all femora and abdomen reddish-ferruginous; all tibiae and tarsi rufo-piceous; narrow lines on posterior and anterior orbits and line on vertex opposite top of eye, anterior margin of pronotum behind occiput, yellowish-white; labrum and mandible in middle rufo-piceous.

Holotype.—Female, Nevada, in Academy of Natural Sciences, Philadelphia, Pa.

Paratype.—1 female, Wallace, Idaho, May 14, 1938, Otto Huelleman (MU).

Remarks.—This species appears closely allied to *ocellaris*, but is apparently distinct in black coxae and shorter ovipositor.

Cryptus minimus, new species

Fig. 46

Female.—Length 8 mm.; ovipositor 4 mm.

Head finely coriaceous, subpolished, with short, somewhat appressed pubescence; genae strongly, convexly narrowed behind eyes; post-ocellar line slightly longer than ocell-ocular line, 1.8 times as long as an ocellus; occiput deeply concave; frons barely excavated, coarsely coriaceous; face twice as wide as high, with a median elevation; clypeus convex with highly polished, slightly reflexed, subtruncate margin; labrum projecting; malar space subequal to basal width of mandible; mandible 1.5 times as long as basal width of mandible; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 26-segmented, first flagellar segment 6 times as long as wide, as long as third and fourth segments together.

Pronotum finely rugulose throughout, with sharp epomia; mesoscutum polished, densely punctate, notaulices strongly impressed, subfoveolate, extending posteriorly as far as middle of tegula; scutellar fovea longitudinally rugose; scutellum narrow, minutely punctae; prepectoral carina complete, extending to subalar tubercle; sternaulus complete, rugose; mesopleura, metapleura, and propodeum rugulose; speculum shining, densely punctate; propodeum with basal and apical transverse carinae complete, posterior carina much stronger than basal, especially laterally; propodeal spiracle small, twice as long as wide.

Legs clothed with pale, somewhat appressed pubescence; hind femur about 5 times as long as wide, hind tibia 1.5 times as long as hind femur, longer tibial spur 0.3 as long as first segment of hind tarsus; anterior tibia strongly swollen and gradually constricted at base (fig. 46); tarsi simple; claw small, finely pectinate, pecten not ending in one large, terminal tooth.

Areolet strongly convergent, first intercubitus reclivous, second intercubitus inclivous, anterior side subequal to second abscissa of cubitus; second recurrent vein staight on posterior half, curved on anterior half, received beyond middle of areolet; ramellus distinct.

Abdomen finely coriaceous except petiole which is depressed, and transversely rugulose laterally, postpetiole about 3 times as wide as petiole, dorsal carinae strong, fading out opposite spiracles; second tergite 1.3 times as long as basal width, posterior margin 1.5 times as wide as base; third tergite 1.3 times as wide as long; following tergites successively shorter and narrower; ovipositor sagittate, sheaths as long as tergites 2-4.

Ferruginous, with the following parts pale yellow: orbits completely encircling eyes, but very narrow in malar space, bases of mandibles, tegulae and subalar tubercle; antennae fuscous, with segments 6-8 yellowish; teeth of man-

dible and sheath of ovipositor blackish; wings hyaline, tinged with pale ferruginous; veins and stigma dark ferruginous.

Holotype.—Female, Oakley, Idaho, August 8, 1928, on S(alsola) *pestifer*, Cat. No. 55436, U. S. National Museum, Washington, D. C.

Male unknown.

Paratypes.—ALBERTA: Lethbridge; COLORADO: "Colorado"; Ridgeway; IDAHO: Oakley on *Sophia sophia* and *Salsola pestifer;* Tuttle on *Iva axillaris;* MONTANA: Bozeman; Gallatin County; Huntley; Jefferson County; Missoula; Willow Creek; NORTH DAKOTA: Watford City; OREGON: Mt. Hood; WASHINGTON: Pullman; WYOMING: Horse Creek; Cheyenne. Specimens collected from May until mid-August. Paratypes in USNM, CN, AMNH, MU, MONT, AES.

Remarks.—Small specimens of this species are the smallest Nearctic *Cryptus*. Its pale brownish color, anteriorly convergent areolet, distinctly curved second recurrent vein, and strongly swollen anterior tibiae should distinguish it from all other *Cryptus*. The type is largely ferruginous or pale brownish, but some paratypes have black stains on frons, vertex, occiput, and thoracic sutures. The number of flagellar segments varies from 25-28; size 6-10 mm.

CRYPTUS VIDUATORIUS Fabricius

Cryptus viduatorius Fabricius, 1805. Syst. Piez.: 70, no. 2. female; Kirby, 1937, Fauna Bor.-Amer., **4**:259, no. 359, female; Bethune, 1877, Can. Ent., **9**:149, female; Morley, 1910, Entomologist, **43**:242-244.

This bibliography includes references only to the original description and the American literature. The European literature is well-covered in Dalla Torre (1902) and Schmiedeknecht (1906). *C. viduatorius* Fab., the genotype, is black, 8-10 mm. long, with coxae and trochanters black and the rest of the legs reddish; scutellum white in both sexes and second recurrent vein straight on posterior half, distinctly curved on anterior half. It is similar to *iroquois* Viereck, but easily distinguished by the key characters. Morley (1910) wrote that *viduatorius* was not known to occur outside Europe, and it has been recorded from America only by Kirby and then only with the brief reference as taken at Lat. "54°". Morley (1910) wrote that *viduatorius* is the only one of the five ichneumon flies in the Fauna Boreali-America that is missing from the collection in the British Museum. Although Kirby's description is excellent and certainly applies to *viduatorius*, it is possible that he did have a specimen of *altonii* D. T. (which occurs in Labrador) and that he merely copied the description of *viduatorius* from European works. Until a specimen is actually collected in North America, it seems wisest to view the Kirby record with suspicion.

Cryptus rufovinctus, new species

Fig. 68

Itamoplex tejonensis Lathrop and Black, 1921, Third Crop Pest and Hort. Report for 1915-1920; 63.—Essig, 1926, Insects West. N. Am.: 799. (Not Cresson 1878).

Female.—Length 12 mm.; ovipositor 7 mm.

Head finely coriaceous, rather densely and finely punctate, densely clothed with short, somewhat appressed, silvery-white pubescence; genae densely, finely punctate, strongly and obliquely narrowed behind eyes, somewhat convex;

postocellar line 1.5 times as long as ocell-ocular line, ocell-ocular line slightly longer than diameter of lateral ocellus; occiput deeply concave; vertex finely densely punctate; eyes parallel, slightly divergent below antennal foramina; frons moderately deeply excavated, more or less transversely rugulose-striate; face nearly twice as wide as high, with strong median elevation; clypeus convex with a narrow, highly polished, slightly reflexed margin; malar space slightly longer than basal width of mandible; mandible 1.5 times as long as wide; antennae 0.7 as long as body, flagellum 41-segmented, first flagellar segment 7 times as long as wide, following segments successively shorter and more slender, third and fourth segments together about as long as first.

Thorax with silvery-white, somewhat appressed pubescence; pronotum more or less longitudinally rugose between epomiae and rugulose striate laterally, with a sharp and conspicuous epomia; mesoscutum polished, densely punctate, more strongly so in front of scutellar fovea; notaulices strong, subfoveolate, extending posteriorly to a line drawn tangential to posterior margins of tegulae; scutellar fovea deep, longitudinally rugose; scutellum polished, finely and sparsely punctate; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete; speculum elevated, polished, impunctate; mesopleura, metapleura, and propodeum reticulate-rugulose; propodeum with basal and apical transverse carinae present, apical carina stronger and produced laterally as short apophyses; propodeal spiracle 3 times as long as wide.

Legs long and slender, coxae densely and closely punctate, with short, somewhat appressed pubescence; hind femur 6 times as long as high, hind tibia 1.3 times as long as femur, longer hind tibial spur 0.45 as long as first segment of hind tarsus; tarsi normal; claw small, finely pectinate at base, with large terminal tooth in pecten.

Areolet strongly anteriorly convergent, first intercubitus reclivous, second intercubitus inclivous; anterior side of areolet subequal to second abscissa of cubitus; second recurrent vein straight on posterior half, distinctly curved on anterior half; ramellus present.

Abdomen finely coriaceous, subpolished; petiole depressed, laterally transversely rugulose; postpetiole 3 times as wide as petiole, dorsal carinae somewhat elevated; second tergite nearly as long as wide at base, posterior margin 1.6 times as wide as postpetiole; third tergite 0.75 as long as wide; following tergites successively shorter and narrower; ovipositor sagittate, as long as abdomen beyond first tergite, with about 9, fine, ventral teeth at tip; sheaths broken in holotype, but in paratypes about as long as abdomen beyond first tergite.

Black; scape, clypeus, base of mandible, palpi, anterior dorsal margin of pronotum, subalar tubercle, legs and abdomen entirely reddish-ferruginous; wings fuliginous, veins and stigma black; narrow lines on anterior and posterior orbits, and line opposite top of eye, yellowish-white.

Male.—Length 8 mm.

Differs from preceding description of female as follows: genae more slender; malar space two-thirds as long as basal width of mandible; flagellum 37-segmented with segments subcylindrical and basal segments shorter; propodeal spiracle 2.5 times as long as wide; propodeal carinae weaker and apical

transverse carina not produced laterally; abdomen more slender; male genitalia and subgenital plate (fig. 68).

Black, with the following parts yellowish-white; broad anterior orbits including malar space, narrow line opposite top of eye and narrow posterior orbits, median elevation of face, clypeus and spot on mandible, tegulae, and subalar tubercle; legs and abdomen reddish-ferruginous; palpi, ventral surface of anterior coxae, and segments 2-4 of hind tarsi pale ferruginous; first segment of hind tarsus infuscated.

Holotype.—Female, Concord, California, September 24, 1919, M. C. Lane, Cat. No. 55435, U. S. National Museum, Washington, D. C.

Allotype.—Male, Burns, Oregon, June 12, 1919, B. G. Thompson ex *Synanthedon bibiopennis*, in U. S. National Museum, Washington, D. C.

Paratypes.—CALIFORNIA: Carmel; Concord; Davis; Hospital Canyon; Lake Merritt in Alameda County; Milbrae in San Mateo County; Hills behind Oakland, Oakland; Redlands; Palo Alto; Panoche Cyn. in Fresno; San Jose as parasite of *Sannin oidea opalescens;* Mojave River in Victorville; Ventura bred from *Etiella zinckenella;* Westwood hills in Los Angeles County; IDAHO: Boise; NEVADA: Reno; OREGON: Blooming; Burns ex *Synathedon bibiopennis;* Cornelius, Roseburg (2 females taken June 25, 1919 by A. B. Black, Par. *Saninoidea opalescens* now in the USNM are probably the specimens determined by Cushman as *Cryptus tejonensis* Cresson and published as *tejonensis* by Lathrop and Black in 1921); Delake; Forest Grove; Summer Lake; WASHINGTON: Almota; Barnes State Park; Lake Paha; Pullman; Toppenish; Yakima; Wawawai; Wenatchee; Washington Territory. Probably occurs on the wing throughout the year. Specimens have been collected in January, March, April, May, June, July, August, September, October. Paratypes in USNM, CAS, MU, UCLA, OR, CU, BS, WASH, AES, TOW.

Remarks.—Easily distinguished from other *Cryptus* with red legs and abdomen by its strongly convergent areolet and the distinctly curved, second recurrent vein. It appears to be confined to United States west of the Rocky Mountains, but may occur in British Columbia.

CRYPTUS ALBITARSIS ALBITARSIS (Cresson)

Figs. 36, 44, 69

Ichneumon vinctus Say, 1829, Contrib. Maclur Lyc. Phil., **2**:70, no. 4, male.—Leconte, 1859, Writ. Th. Say Entom., **1**:375, no. 4, male. (Not Schrank 1781)—Cresson, 1877, Trans. Amer. Ent. Soc., **6**:207, male.

Ischnus albitarsis Cresson, 1864, Proc. Ent. Soc. Phil., **3**: 194, no. 12. male. (not *Cryptus albitarsis* Cresson, 1864, Proc. Ent. Soc. Phil., **3**:300, male).

Cryptus americanus Cresson, 1864, Proc. Ent. Soc. Phil., **3**:297, no. 11, female.—Cresson, 1872, Trans. Amer. Ent. Soc. **4**:157, female.—Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, pt. 1: 79, female.—Provancher, 1874, Nat. Can., **6**:177 and 202, no. 13, female.—Provancher, 1875, Nat. Can., **7**:177 female.—Provancher, 1879, Nat. Can., **11**:131 and 135, no. 11, male and female.—Provancher, 1883, Pet. Faunn. Ent. Can. Hym., **2**:333, no. 11, female and male.—Provancher, 1886, Add. Faun. Ent. Can. Hym.: 63, 66, male and female.—Riley, 1890, Insect Life, **3**:153.—Bridwell, 1899 Trans. Kans. Acad. Sci. **16**:204.—Ashmead, 1900, Smith's Insects N. J. :570.—Washburn, 1918, 17th Rept. St. Ent. Minn. : 172, female.—Procter, 1938, Insect Survey Mt. Desert Region, Pt. 6, 402.

Cryptus albitarsis (Cresson) Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, Pt. 1: 77, male.

Cryptus nigricalceatus Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, pt. 1: 76, male.

Cryptus nigricornis Provancher, 1874, Nat. Can., **6**: 177 and 201, no. 9, male. (not Brulle 1846).—Provancher, 1875, Nat. Can., **7**: 177, male.—Provancher, 1879, Nat. Can., **11**:139, male.—Provancher, 1883, Pet. Faun. Ent. Can. Hym., **2**:338, no. 21, male.—Provancher, 1886, Add. Faun. Ent. Can. Hym.: 66, male.—Ashmead, 1900, Smith's Insects N. J.: 570.

Mesostenus tarsatus Provancher, 1875, Nat. Can., **7**: 265, no. 10, male.

Nematopodius coxatus Provancher, 1875, Nat. Can., **7**:269, no. 10, male.

Hoplismenus impar Provancher, 1879, Nat. Can., **11**:3, no. 3, female. (not male as described).—Provancher, 1883, Pet. Faun. Ent. Can. Hym., **2**:292, no. 3, female (not male as described).

Cryptus impar (Provancher) Davis, 1894, Proc. Acad. Nat. Sci. Phil. : 185.

Spilocryptus canarsiae Ashmead, 1897, Proc. Ent. Soc. Wash., **4**: 124, male.—Johnson, 1927, Biol. Surv. Mt. Desert Region, Pt. **1**:141.—Procter, 1938, Insect Survey Mt. Desert Region, Pt. **6**:402.

Itamoplex americanus (Cresson) Ashmead, 1900, Smith's Insects N. J.: 570.—Viereck, 1910, Smith's Insects N. J.: 630—Johnson, 1927, Biol. Surv. Mt. Desert Region, Pt. **1**:140.

Cryptus purneri Dalla Torre, 1902, Cat. Hym., **3**, pt. 2: 585 (new name for *nigricornis* Provancher, 1874, not Brulle, 1846).

Cryptus vinctus (Say) Davis, in Nason, 1905, Ent. News. **16**:151.—Cushman, 1921, Journ. Wash. Acad. Sci., **15**: 390.—Johnson, 1927, Biol. Surv. Mt. Desert Region, Pt. 1: 141.—Cushman, 1928, Leonard's Insects N. Y., Corn. Agr. Exp. Sta. Mem. 101: 931.—Stearns, 1928, N. J. Agr. Exp. Sta. Bull., 460: 6.—Cushman, 1929, Proc. U. S. Nat. Mus., **74**, art 16, (No. 2761): 58.—Haeussler, 1930, Journ. Agr. Res., **41**(5):366.—Johnson, 1930, List. Insect Faun Nantucket: 100 (in part).—Walley, 1931, 61st Ann. Rept. Ent. Soc. Ont.: 92.—Procter, 1938, Insect Survey Mt. Desert Region, Pt. 6: 402.—Brimley, 1938, Insects N. Car. : 407.

?*Cryptus lavogleri* (Dalla Torre) Viereck, 1910, Smith's Insects N. J. : 630.

Agrothereutes (Itamoplex) americanus (Cresson) Viereck, 1916, Hym. Conn., Geol. N. H. Surv. Bull. **22**:332-333.—Britton, 1920, Conn. Geol. N. H. Surv. Bull. **31**: 315, female.—Britton, 1938, Add Check List Conn., Bull. St. Geol. N. H. Surv. **60**:126.

Itamoplex vinctus (Say) Cushman and Gahan, 1921, Proc. Ent. Soc. Wash., **23**, no. 7: 168.—Champlain, 1922, Psyche, **29**: 99.

The species is very variable and the following descriptions of male and female are based on all the types and many other specimens.

Female.—Length 6-12 mm., ovipositor 3-7 mm.

Head finely coriaceous, densely clothed with more or less appressed, short, silvery pubesecnce; genae subpolished, minutely and densely punctate, strongly narrowed behind eyes, slightly convex; post-ocellar line 1.3-1.8 times longer than ocell-ocular line and 1.5-2 times as long as diameter of an ocellus; occiput deeply concave; frons moderately excavated, irregularly rugulose, somewhat transversely rugose, but entirely without a ridge behind each antennal foramen; face almost twice as wide as high, with a prominent median elevation; clypeus always convex, with a thin, slightly reflexed, highly polished margin; labrum projecting; malar space shagreened, usually slightly longer than basal width of mandible; mandible about 1.5 times as long as basal width; occipital carina joining hypostomal carina about basal width of mandible from mandible; antenna slender, 0.8 as long as body, flagellum 35-40-segmented, first segment 5-7 times as long as wide, second about 0.8 as long as first, third 0.7 as long as first, following segments successively shorter and narrower.

Thorax densely clothed with short, appressed, silvery-white pubescence; pronotum longitudinally striate on dorsal portion between epomiae, lateral

portion punctate above becoming irregularly longitudinally rugulose below, epomia strong, curving anteriorly; mesoscutum shining, densely and finely punctate; notaulices strong, minutely foveolate, extending posteriorly as far as posterior margin of tegula; scutellar fovea longitudinally rugose; scutellum convex, polished, very minutely punctate; prepectoral carina complete, extending to subalar tubercle; sternaulus complete; mesopleura coarsely and sometimes finely punctate; speculum finely punctate, not strongly elevated; metapleura and propodeum punctate-rugulose; propodeum often with a triangular, median basal area; propodeum with basal and apical transverse carinae present, apical carina much stronger than basal, produced laterally into short, lamellate apophyses; propodeal spiracle 2-3 times as long as wide.

Legs rather slender, coxae densely punctate and like rest of legs densely clothed with short, somewhat appressed pale pubescence; hind femur 6 times as long as high; hind tibia 1.3 times as long as hind femur, longer spur 0.4 as long as first segment of hind tarsus; anterior tarsus normal; claws short, with fine pectination at base and no large terminal tooth in pecten (fig. 36).

Areolet strongly convergent anteriorly, first intercubitus reclivous, second intercubitus inclivous, anterior side 0.4 as long as first intercubitus; second recurrent vein distinct curved on anterior half, straight on posterior half, received beyond middle of areolet; ramellus distinct (fig. 44).

Abdomen stout, finely coriaceous except petiole which is polished dorsally and transversely rugose laterally, petiole depressed, postpetiole 3 times as wide as petiole, dorsal carinae distinct, fading out opposite spiracles; second tergite 0.8 as wide at base as long, base about 0.7 as wide as posterior margin; third tergite 1.3-1.6 times as wide as long; following tergites successively shorter and narrower; ovipositor sagittate, sheaths as long as abdomen beyond first tergite.

Black; apices of flagellar segments narrowly piceous, and apical flagellar segments often entirely piceous; anterior and middle tibiae and tarsi; and a very narrow, basal annulus on all femora rufo-piceous; abdomen bright reddish-feruginous, base of first tergite more or less infuscated; dot on vertex opposite top of eye, narrow lines on anterior and posterior orbits, sometimes dots on malar space, clypeus, and more or less palpi yellowish-white.

Male.—Differs from female in having genae less strongly narowed behind eyes; antennae longer, with segments cylindrical throughout, not apically expanded; propodeum longer and more gradually sloping from base to apex, apical transverse carina weaker and not produced laterally; petiole more cylindrical, with longitudinal carinae weaker, and side of petiole weakly or not at all trnsversely rugose, sternite extending posteriorly beyond spiracle, postpetiole not more than twice as wide as petiole; abdomen more slender, second tergite 3-4 times as long as basal width; subgenital plate and genitalia (fig. 69).

Extremely variable in amount of white markings but typically with the following parts white; posterior orbits narrowly, facial orbits broadly, a bilobed spot on median elevation of face, clypeus except apical margin, malar space, scape beneath, labrum, spot on mandible, palpi, lines on dorsal and ventral margins of pronotum, tegulae, subalar tubercle, spots on anterior and middle coxae and trochanters, more or less of inner face of anterior and middle

femora, almost all of four anterior tibiae and tarsi, usually segments 2-4 of hind tarsus and sometimes part of segment 1, scutellum and postscutellum; abdomen reddish-ferruginous, base of first tergite, subgenital plate, genitalia, and postgenital segments blackish; the face may be entirely white due to fading out of the black lines beneath antennae, of the white markings may be reduced in melanistic specimens; the white markings may have yellowish or reddish tinge, especially in specimens which have been kept too long in the cyanide jar.

Female.—Female, the lectotype of *Cryptus americanus* Cresson, Delaware, No. 1128, Academy of Natural Sciences, Philadelphia, Pa.

Lectotype.—Male, the lectotype of *albitarsis* is No. 1127 in the Academy of Natural Sciences, Philadelphia, Pa.

The types *vinctus, nigricalceatus, tarsatus,* and *coxatus* are lost. The type of *nigricornis* bears Yellow label 291 in the First Provancher collection and the type of *impar* bears Yellow label 168 in the Second Provancher Collection, Public Museum, Quebec, Canada. The type of *canarsiae* is in the Illinois State Natural History Survey collection, Urbana, Illinois.

Distribution.—CONNECTICUT: Branford, Darien, New Canaan, New Haven, Prospect, Stonington, West Haven; ILLINOIS, Algonquin, Carbondale, Chicago, Elgin, Galesburg, Grand Tower, Havana, Ludlow, Metropolis, McHenry, Monticello, Normal, Ottawa, Princeton, Richview, Odin, Savanna, Urbana, Wordworth; INDIANA. IOWA: the following counties: Emmet, Kossuth, Mitchell, Cerro Gordo, Clayton, Butler, Vremer, Dubuque, Benton, Johnson, Washington, Henry, also Mt. Pleasant township; MAINE: Bar Harbor, Mt. Cadillac, Mt. Desert Island, Casco Bay, Salisbury Cove, S. W. Harvard, Brooksville; MARYLAND: Cabin John, Glen Echo; MASSACHUSETTS: Amherst Auburndale, Boston, Brookline, Cambridge, Cohasset, Duxbury, Forest Hills, Great Barrington, Lexington, Mallden, Middlesex Falls, Nantucket, Provincetown, Salem, Wellfleet, Wood's Hole; MICHIGAN: Bay County, Genessee County, Gladwin County, Midland County; MINNESOTA: Baudette, Cass County, Fillmore County, Fort Snelling, Goodhue County, Hennepin County, Houston County, Lancaster, Luverne, Mille Lacs, Norman County, Ottertail County, Pennington County, Pope County, Ramsey County, Rock County, St. Anthony Park, Sibley County, Sherburne County, St. Paul, Traverse County, Washington County, Winona County; NEW BRUNSWICK: Newcastle, Shippigan; NEW HAMPSHIRE: Compton, Glen House, Intervale; NEW JERSEY: Boonton, Clementon, Clifton, Moorestown, Rancocas Park, New Brunswick; NEW YORK: New York, Adirondack Mts., Bayville, Beaverkill, Catskill Mts., Ithaca, Freehold, Niagara Falls, Penn Yan, Rock City, Sea Cliff on Long Island, Taughanic Falls, Thousand Islands, Yonkers; NORTH CAROLINA: Valley of Black Mts.; NOVA SCOTIA: Kentville, Truro; OHIO: Fayetteville, Logan County; OKLAHOMA: Broken Bow; ONTARIO: Bobcaygeon, Constance, Kearney, Niagara Glen, Orilla, Simco, Wabamic; PENNSYLVANIA: Carlisle, Lehigh, Leopard, Wissahickon Valley, Pennyhack, Philadelphia; SOUTH CAROLINA: Clemson College; QUEBEC: Queen's Park in Aylmer, Hemmingford, Knowlton, Montreal Island, St. Hilaire; SOUTH DAKOTA: Brookings, Capa, Gregory, Harney Peak, Lake Hendrickson, Newel, Pringle, Rapid Canyon, Springfield, Warren's Woods, Waubay; VERMONT: Jacksonville, Rutledge, South Hero, Whitingham, Wilmington; VIRGINIA: Falls Church, Glencarlyn, Great Falls, Paeonian Springs; WISCONSIN: Cranmoor, Sawyer County, St. Croix Falls. Specimens collected in the field from April until November. Specimens in USNM, AES, AMNH, MCZ, CN, CONN, ILL, W, IOWES, TOW, NMNH, MSC, D, MU, HOP, CU, SD.

Remarks.—Say overlooked *Ichneumon vinctus* Schrank (1781) and described his *Ichneumon vinctus* in 1829. In all probability this specimen has been destroyed by pests with the majority of the Say collection. G. C. Davis was the first to recognize *vinctus* Say again in 1905, and his specimen is in the Illinois State Natural History Survey Collection. This generic transfer was

overlooked for many years, and, for all practical purposes, recognition of the species must go to Cushman and Gahan who transferred *Ichneumon vinctus* Say to *Itamoplex* and designated a neotype in 1921. Cresson described male and female in 1864 as *Ischnus albitarsis* and *Cryptus americanus* respectively. A further complication arises from the fact that Cresson described a *Cryptus albitarsis* which is a true *Trychosis*, and transferred *Ischnus albitarsis* to *Cryptus* (see note by Cresson in Walsh, 1873, p. 77). Provancher erected three synonyms of *vinctus*, all in the male sex, on color characters of no specific value: *Cryptus nigricornis*, *Mesostenus tarsatus*, and *Nematopodius coxatus*. Provancher himself placed the last two species as synonyms of *americanus*, and, following his custom in such matters, removed the type labels from his two supposed species. The synonymy of *tarsatus* and *coxatus*, therefore, is based on Provancher's own synonymy and the original descriptions. The type of *nigricalceatus* is lost, but there can be little doubt that it is merely a color variety of *albitarsis*. A female specimen with the ovipositor broken off at the base was described as a male *Hoplismenus impar* by Provancher. Davis (1894) recognized that this specimen was a *Cryptus* but he did not place it as a synonym of *albitarsis*. In 1897 Ashmead received a small male, reared from an abnormal host, and described it as *Spilocryptus canarsiae*. In 1902, Dalla Torre found *Cryptus nigricornis* Provancher (1874) preoccupied as *Cryptus nigricornis* Brulle (1846) and renamed *nigricornis* Provancher as *purneri* Dalla Torre. Various authors have contributed to the synonymy of this species and at present *Cryptus albitarsis albitarsis* (Cresson) has no less than nine synonyms.

Within its range *Cryptus albitarsis albitarsis* (Cresson) is the most abundant species of *Cryptus*. The size is very variable and the coloration varies somewhat with the altitude and latitude. Specimens from the north and those taken at high elevations being darkest. The amount of white in the male is very variable and has led to the description of a number of synonyms. The occipital carina often joins the hypostomal carina less than the basal width of the mandible from the mandible.

CRYPTUS ALBITARSIS COLORADENSIS Ashmead

Cryptus coloradensis Ashmead, 1890, Proc. U. S. National Museum, **12**: 408, female.—Knowlton & Harmston, 1939, Utah Acad. Sci. Arts and Lett., **16**:61.

Cryptus consobrinus Viereck, 1906, Trans. Amer. Ent. Soc. **32**: 225, female. (New synonymy).

Cryptus albitarsis (Cresson) Viereck, 1906, Trans. Amer. Ent. Soc., **32**:183, male.

Except for the darker wings of the female and the immaculate scutellum of the male, there appear to be no constant characters to separate this western subspecies from the Eastern subspecies.

Specimens of *albitarsis coloradensis* vary from 6-15 mm. in length. The large specimens have coarser punctation on pleura and speculum, propodeal longer, and often the base of the scutellum slightly margined. The base of the first tergite in most specimens examined has relatively more black than specimens of the eastern subspecies *albitarsis albitarsis*, but this is not a constant character. The amount of white on legs, face, and pronotum is also less than in

albitarsis albitarsis, but this is also a variable character. The tegulae are black, white, or black and white in the male.

Holotype.—Female, Powder River, Colorado, Cat. No. 2021, U. S. National Museum, Washington, D. C.

The type of *consobrinus* is in the University of Kansas, Lawrence, Kansas.

Distribution.—ALASKA: Skagway; ALBERTA: Calgary, Lethbridge, Medicine Hat; ARIZONA: "Southern Arizona," Chiracahua in Cohise Co., Fish Creek in Tonto National Forest, Groom Creek, Huachuca, Jerome; the type of *consobrinus* is from Oak Creek Canyon, 6000 ft. F. H. Snow; Palmerlee; BRITISH COLUMBIA: Victoria; CALIFORNIA: Angora, Mono County, Santa Cruz Islands, Westwood Hills in Los Angeles County; COLORADO: Alamosa, Boulder, Long's Peak in Boulder County, Camp Creek Station, Cripple Creek, Colorado Springs, Delta, Denver, Electra, Mt. Manitou in El Pasa County, Fort Collins, Grand Mesa, Lamp Gulch, Morrison, Salida, Ward, Yampa; IDAHO: American Falls, Tuttle; KANSAS: Lawrence (Viereck's 1906 record of *albitarsis* Cresson); MANITOBA: Aweme, The Pas, Teulon; MINNESOTA: Baudette, Hallock, Itasca Park, Kittson Couny, Lutsen, Marshall County, Mille Lacs, North Cheyenne River in Lisbon; NEW MEXICO: Fort Wingate; UTAH: Allen Canyon, Shields River, Sidney; NEBRASKA: Mitchell; NEVADA: Reno; NORTH DAKOTA: Branch, Polk County; MONTANA: Big Horn County, Bozeman, Gallatin, Helena, Boulder, Card Canyn, Fielding, Ft. Duchesne, Logan, Murray, Navajo Lake, Park Valley, West Point; WASHINGTON: Wawawai. In flight during May, June, July, and August throughout most of its range. In Westwood Hills, Los Angeles County, California the Boharts have collected this subspecies on January 19 and 20, 1940. Specimens in USNM, AES, CAS, KU, MU, CU, MCZ, UCLA, FC, C, AMNH, CN, MONT, UTAH.

Remarks.—Ashmead, in describing *coloradensis,* and Viereck, in describing *consobrinus,* noted that the female differed from *americanus* Cresson essentially by its black or dark smoky wings. The type of *coloradensis* Ashmead is small, 7.4 mm. long, and is typical of many of the Rocky Mountain specimens studied. The type of *cconsobrinus* Viereck is large, 13 mm., with very coarse punctation especially on the pleura, and the base of the scutellum is slightly margined. In size and sculpture the type of *consobrinus* Viereck is typical of many Pacific Coast specimens from Los Angeles to British Columbia. All intergrades, however, occur without regard to geographical distribution, and it seems wisest to consider them as the same subspecies. The dark wing color serves to distinguish *albitarsis coloradensis* females from the eastern *albitarsis albitarsis* but does not always serve to distingusih males. The entirely black scutellum does seem to separate the western males from the eastern males of *albitarsis albitarsis* with the white or white-marked scutellum. When a large series is studied, two distinct groups based on color and geographical distribution can be easily distinguished except in the intermediate geographical region where the two subspecies appear to interbreed or hybridize. This region extends from western and northern Minnesota through Kansas to New Mexico.

Cryptus curticaudus, new species

Female.—Length 6 mm., ovipositor 2 mm.

Head with sparse, silvery-white pubescence; genae narrower dorsally than ventrally, finely punctate, slightly convexly narrowed behind eyes; ocell-ocular line subequal to diameter of lateral ocellus, 0.7 as long as post-ocellar line; occiput shallowly concave; vertex finely punctate; frons slightly excavated,

punctate dorsally, more polished, but entirely without vertical ridge, behind each antennal foramen; face twice as wide as high, with a median elevation; clypeus moderately convex, with a slightly reflexed, polished, apical margin; malar space 1.3 times as long as basal width of mandible; mandible 1.7 times as long as basal width; occipital carina joining hypostomal carina slightly less than basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 35-segmented, first segment 5 times as long as wide, second 0.8 and third 0.6 as long as first segment.

Pronotum punctate rugulose, with distinct epomia; mesoscutum finely and densely punctate; notaulices extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum convex, subpolished, weakly punctate; prepectoral carina complete, attaining subalar tubercle; sternaulus complete, subfoveolate; speculum slightly elevated, a little less densely punctate than rest of mesopleurum; mesopleura, metapleura, and propodeum rugulose-punctate; propodeum with basal transverse carina weak, apical carina strong; propodeal spiracle 1.8 times as long as wide.

Coxae finely and densely punctate; hind femur 5 times as long as high; hind tibia 1.2 times longer than hind femur, longer tibial spur 0.4 times as long as first segment of hind tarsus; anterior tibia gradually expanding from base to tip, not strongly swollen and basally constricted as in *persimilis;* tarsi normal; claw small, weakly pectinate at base, pecten not ending in one conspicuously large tooth.

Fore-wing with areolet broadly convergent anteriorly, first intercubitus slightly reclivous, second intercubitus strongly inclivous, anterior side 0.7 as long as first intercubitus; second recurrent vein curved on anterior half, straight on posterior half, received slightly beyond middle of areolet; ramellus present.

Abdomen finely coriaceous, except petiole which is depressed and subpolished, somewhat transversely rugulose laterally; postpetiole 3 times as wide as petiole, dorsal carinae present, fading out opposite spiracles; second tergite 1.3 times as wide at posterior margin as at base, 0.8 as long at posterior margin; third tergite 1.5 times as wide as long; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor 1.6 times as long as first tergite, as long as tergites 2-4.

Black; hind femora and abdomen entirely reddish-ferruginous; anterior and middle femora, tibiae, and tarsi rufo-piceous; tip of hind femur, hind tibia, and basal and apical segments of hind tarsus dull blackish; base of first abdominal segment and segments 2-4 of hind tarsus, piceous; wings hyaline-infumate; stigma entirely, and veins distally, pale brown, increasingly piceous towards base.

Holotype.—Female, Crookston, Minnesota, September 2, 1935, D. G. Denning, in Collection University of Minnesota, St. Paul, Minn.

Paratypes.—all female: one, Argyle, Minnesota, September 7, 1935, D. G. Denning (MU); two from Colorado (AES, MU); one, Bozeman, Mont., 4800 feet, July 22, 1901, E. J. S. Moore (MONT).

Remarks.—Closely allied to *persimilis* in general coloration, size, and distri-

bution. It differs in the largely reddish first tergite, uniformly dull black hind tibia, anterior tibia increasing gradually in diameter, and shorter ovipositor.

Cryptus areolatus, new species

Fig. 43

Female.—Length 9.5 mm.; ovipositor 4.5 mm.

Head with short, somewhat appressed, silvery-white pubescence; genae polished, finely and densely punctate, strongly and obliquely narrowed behind eyes, slightly convex; post-ocellar line subequal to ocell-ocular line, 1.5 times as long as diameter of lateral ocellus; occiput deeply concave; frons coriaceous above, transversely rugulose behind antennal foramina, rather shallowly excavated and vertical ridge behind each antennal foramen; face 2.2 times as wide as high, with a distinct median elevation; clypeus strongly convex, with a narrow, highly polished, slightly reflexed margin; labrum projecting; malar space subequal to basal width of mandible, shagreened; mandible 1.4 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.8 as long as body, broken in type, but more than 25-segmented, first flagellar segment 7 times as long as wide, second 0.7 as long as first, third 0.6 as long as first.

Pronotum coarsely rugulose, with distinct epomia; mesoscutum polished, finely and densely punctate, notaulices deeply impressed anteriorly and probably extending posteriorly to a line tangential to posterior margins of tegulae (the pin obscures this character); scutellum slightly convex, polished and punctate; prepectoral carina extending 0.7 distance to subalar tubercle; sternaulus complete, deeply impressed, especially anteriorly, subfoveolate; mesopleura, metapleura, and propodeum coarsely, reticulately, rugulose-punctate; speculum slightly elevated, finely punctate, polished; propodeum with both basal and apical transverse carinae present and strong, apical carina straight in middle, laterally produced into short, lamellate apophyses; propodeal spiracle 2.5 times as long as wide.

Coxae polished, finely and densely punctate, with short, somewhat appressed silvery-white pubescence; hind femur 6 times as long as high; hind tibia 1,2 times as long as hind femur, longer hind tibial spur 0.3 as long as first segment of hind tarsus; anterior tibia slightly convexly swollen from base to distal fourth, then gradually decreasing in diameter to tip; tarsi normal; claw small, with fine pectination and bristles at base, but no strong terminal tooth in pecten.

Areolet 4-sided, intercubiti contiguous on anterior side, first intercubitus strongtly reclivous, second intercubitus strongly inclivous; second recurrent vein straight on posterior half, distinctly curved on anterior half, received beyond middle of areolet; ramelius long; nervulus antefurcal (fig. 43).

Abdomen coriaceous; petiole depressed and polished, slightly rugulose laterally; postpetiole 3 times as broad as petiole, dorsal carinae present but not strong; second tergite 1.3 times as long as basal width; third tergite 1.5 times wider than long; following tergites transverse, successively narrower and

shorter; ovipositor compressed, sagittate; sheaths of ovipositor as long as abdomen.

Black; abdomen except base of first tergite, and hind femora reddish-ferruginous; all tibia and tarsi piceous; head entirely black except for very narrow posterior orbits which are yellowish-white; wings yellowish-hyaline, veins and stigma piceous.

Holotype.—Female, Mammoth, California, July 23, 1933, probably collected by R. M. or G. E. Bohart, Cat. No. 5211, California Academy of Sciences, San Francisco, Calif.

Remarks.—The unique female is distinct from other species with distinctly curved second recurrent vein in its quadrangular areolet, form of anterior tibia, long first flagellar segment, and coarsely sculptured pleura.

CRYPTUS PERSIMILIS Cresson

Figs. 24, 31, 70

Cryptus persimilis Cresson, 1864, Proc. Ent. Soc. Phil., **3**: 298, no. 12, female.—Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, pt. 1: 78, female.—Provancher, 1874, Nat. Can. **6**: 177 and 203, no. 15, female.—Provancher, 1875, Nat. Can. **7**: 177, no. 15, female.—Provancher, 1879, Nat. Can., **11**:136, no. 14, female.—Provancher, 1883, Faun. Ent. Can. Hym., **2**: 329 and 335, no. 14, female.—Provancher, 1886, Add. Faun. Ent. Can. Hym: 63, no. 14, female.—Washburn, 1918, 17th Rept. St. Ent. Minn.: 172.—Johnson, 1927, Biol. Surv. Mt. Desert Region, **1**: 141.—Cushman, 1928, in Leonard's Insects of N. Y., Corn. Univ. Agr. Exp. Sta. Mem. 101: 931.—Johnson, 1930, Insect Fauna Nantucket, Mass.: 101.—Procter, 1938, Insect Survey Mt. Desert Region, Pt. 6: 402.—Brimley, 1938, Insects N. Carolina: 407.—Knowlton & Harmston, 1939, Utah Acad. Sci. Arts, Lett., **16**: 61.

Cryptus picticoxus Walsh, 1873, Trans. Acad. Sci. St. Louis, **3**, pt. 1: 82, male.

Cryptus mundus Provancher, 1874, Nat. Can., **6**: 177 and 203, no. 16, male.—Provancher, 1875, Nat. Can., **7**:177, no. 16, male.—Provancher, 1879, Nat. Can., **11**: 137, no. 15, male.—Provancher, 1883, Faun. Ent. Can. Hym., **2**: 329 and 335, no. 15, male.—Provancher, 1886, Add. Faun. Ent. Can. Hym.: 66, no. 15, male.—Viereck, 1910, Smith's Insects N. J.: 630.

Itamoplex persimilis (Cresson) Ashmead, 1900, Smith's Insects N. J.: 570.—Vierek, 1910, Smith's Insects N. J.: 630.

Cryptus citrinimaculatus Viereck, 1905, Trans. Kansas Acad. Sci., **19**:320, male.

Agrothereutes persimilis (Cresson) Viereck, 1916, Hym. Conn., Bull. N. H.

Female.—Length 9 mm.; ovipositor 5 mm.

Head with short, somewhat appressed, silvery-white pubescence; genae polished, finely and densely punctate, strongly, obliquely narrowed behind eyes, slightly convex; post-ocellar line longer than ocell-ocular line, ocell-ocular line 1.5 times as long as diameter of lateral ocellus; occiput deeply concave; vertex punctate; frons finely rugulose, shallowly excavated, more deeply so just behind each antennal foramen; face twice as wide as high, coriaceous, finely and densely punctate with a strong, median elevation; clypeus moderately convex with a narrow, highly polished, slightly reflexed margin; labrum projecting; malar space subequal to basal width of mandible; mandible 1.5 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 33-segmented, first flagellar segment 5 times as long as wide, second slightly shorter, third slightly more than half as long as first.

Pronotum punctate along dorsal margin, finely irregularly rugulose to rugulose-striate below, with distinct epomia; mesoscutum polished, finely and densely punctate, notaulices deeply impressed, almost meeting, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum polished, densely and finely punctate; prepectoral carina strong, attaining subalar tubercle; sternaulus deeply impressed, rugulose, broad; mesopleura, metapleura, and propodeum finely, reticulately, rugulose-punctate; speculum slightly elevated, smooth and polished, with a few fine punctures; propodeum with basal and apical transverse carinae, basal carina weaker, apical carina stronger, especially on lateral angles; propodeal spiracle twice as long as wide.

Coxae finely and densely punctate, with short, somewhat appressed pubescence; hind femur about 5 times as long as high; hind tibia 1.2 times as long as femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tibia strongly and convexly swollen from basal fourth to tip, somewhat constricted basally; tarsi normal; claw small, with fine pectination and no strong, terminal tooth in pecten.

Areolet strongly, anteriorly convergent, first intercubitus reclivous, second intercubitus strongly inclivous, anterior side subequal to first abscissa of cubitus; second recurrent vein distinctly cuved on anterior half, straight on posterior half, received in or beyond middle of areolet.

Abdomen coriaceous; petiole depressed and polished dorsally, transversely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carinae strong, fading out opposite spiracles; second tergite 0.8 as long as first tergite, twice as wide at posterior margin as postpetiole, and 0.7 as long as wide at posterior margin; ovipositor compressed, sagittate; sheaths of ovipositor nearly as long as abdomen, always longer than abdomen beyond first tergite.

Black; abdomen, except petiole, and legs beyond trochanters, reddish-ferruginous; tip of hind tibia and most of tarsi somewhat obfuscated; labrum, narrow lines on anterior orbits complete to top of eye, and posterior orbits, yellowish-white; tegulae rufo-piceous; wings hyaline tinged with fuscous, veins and stigma pale brownish.

Male.—Differs from preceding description of female as follows: malar space 0.7 as long as basal width of mandible, flagellar segments cylindrical, pronotum less strongly punctate, epomia weak; propodeum with both transverse carinae stronger than in female, petiolar area much shorter than in female; abdomen more slender, postpetiole about twice as wide as petiole; male subgenital plate and genitalia (fig. 70).

Black; abdomen, except for black base of tergite 1 and genitalia, all femora and more or less of tibia reddish-ferruginous; yellowing-white markings as follows; narrow posterior orbits, anterior orbits broadest near clypeus, median elevations of face and clypeus, labrum, spot on mandible, tegula, subalar tubercle, spots on anterior and middle coxae and trochanters, and tips of anterior and middle femora; hind tibia distally and all tarsi more or less infuscated, hind tarsi often almost black.

Lectotype.—Female, Delaware, Dr. Thos. B. Wilson, No. 1148, Academy of Natural Sciences, Philadelphia, Pa.

Allotype.—Male, the lectotype of *Cryptus mundus* Provancher is the allotype. Taken presumably in Quebec, Canada, now bears Yellow label 289, First Provancher Collection, Public Museum, Quebec.

The type of *citrinimaculatus* is in the collection of the University of Kansas, Lawrence, Kansas. The type of *picticoxus* appears to have been lost with most of the Walsh collection in the Chicago fire.

Distribution.—BRITISH COLUMBIA: Okanaga, Oliver, Vernon; CALIFORNIA: Sisson, Redwood Canon in Marin County; COLORADO: Boulder, Fort Collins; CONNECTICUT: New Haven, Hartford; ILLINOIS: Algonquin, Champaign, Chicago, McHenry, Muncie, Seymour, Stony Creek, Taylorville, Titus, Urbana; INDIANA: "Indiana"; IOWA: the following counties: Osceola, Dickinson, Emmet, Kossuth, Winnebago, Mitchell, Clay, Palo Alto, Cerro Gordo, Fayette, Plymouth, Buchanan, Dallas, Muscatine, Henry; MAINE: Narrows on Mt. Desert Island: MARYLAND: Cabin John; MASSACHUSETTS: Amherst, Colrain, Groton, Muskaget, Nantucket, North Adams; MICHIGAN: the following counties: Iosco, Isabella, Midland, Ottawa; MINNESOTA: Anoka County, Argyle, Baudette, Beltrami, Browns Valley, Chisago County, Crookston, Fergus Falls, Freeborn County, Goose Lake, Hennepin County, Houston County, Kittson County, Lake Minnetonka, Lake Superior, Lancaster, Mapleplaine, Marshall County, Newport, North Branch, Owatonna, Pipestone, Ramsey County, Powder Plant Woods in New Brighton, Ramsey County, Rochester, St. Anthony Park, U. Farm, Wabasha, Washington County, Winnebago; MONTANA: Big Fork, Bozeman, Florence, Gallatin County, Livingston, Missoula; NEW HAMPSHIRE: Mt. Washington; NEW YORK: Adirondack Mts., Bayville, Buffalo, Cold Spring Harbor, Ithaca, Lancaster, Kirkville, Penn Yann; NORTH CAROLINA: Valley of the Black Mts., Nantahala Gorge; NORTH DAKOTA: Fargo, Solen; NOVA SCOTIA: Truro; OHIO: Logan County; ONTARIO: Lake of Bays, Ottawa, Merivale, Mey Bleue, Strathroy, Smoky Falls on Mattagami River, Wabamic; OREGON: Frog Camp to White Br. Midw nr. McKenzie Pass, 4700 feet; PENNSYLVANIA: Inglewood, Montgomery, Philadelphia; QUEBEC: Aylmer, Cascapedia, Joliette, Landraie, Quebec, Rigand; SOUTH DAKOTA: Brookings, Bigstone; UTAH: Navajo Lake; VERMONT: Bennington, Laurel Lake in Jacksonville, London, Woodstock; WASHINGTON: Pullman, Uniontown, Westport; Taken in the field from April until October. Specimens in USNM, AES, CN, CU, C, MU, ILL, IOWES, NMNH, D, MONT, MSC, MCZ, FC, CAS, AMNH, SD, OR, ND, UCLA, W.

Remarks.—*C. persimilis* occurs throughout northern United States and much of southern Canada. Walsh's description of *picticoxus* agrees very well with the male of *persimilis* except that the first tergite in that species is said to be "rather robust, twice as long as wide." This may be a *lapsus calami* with "twice" for "thrice," for the description has all other salient characters of the male *persimilis* and Walsh himself compared *picticoxus* with *persimilis*. *Cryptus mundus* Prov. agrees well with the male of *persimilis* and the writer's synonymy of the two species has been checked by R. A. Cushman in 1940. *A. citrinimaculatus* Viereck differs chiefly from the male of *persimilis* in having the first tergite largely reddish. A series from South Dakota show all intergradations between completely red and completely black first tergite and this character cannot be considered of specific value. *C. persimilis* should be easily recognized by the strongly convergent areolet and distinctly curved second recurrent vein, reddish hind femora, strongly swollen anterior tibia, and ovipositor as long as abdomen beyond first tergite in the female; while the black face of the male with pale orbital markings and spots on face, clypeus, etc., should distinguish it from its closest relative, *associatus*. In 95% of all the

specimens examined the base of the first tergite in both sexes is largely black, the tips of the hind tibiae and all the tarsi are obfuscated. In both sexes the amount of black at the base and tip of the abdomen is variable. In the male the amount of white markings on the face and legs is subject to considerable variation. Size 6-11 mm.; flagellar segments 31-35.

Cryptus associatus, new species

Figs. 47, 71

Female.—Length 8 mm.; ovipositor 5 mm.

Head with short, somewhat appressed, silvery-white pubescence; genae polished, finely and densely punctate, strongly and obliquely narrowed behind eyes, slightly convex; postocellar line 1.1 times as long as ocell-ocular line, ocell-ocular line 1.5 times as long as diameter of lateral ocellus; occiput deeply concave; frons finely rugulose, shallowly excavated, more polished and deeply excavated behind antennal foramina; face coriaceous, 2.2 times as wide as high, with a strong median elevation; clypeus moderately convex, with a narrow, highly polished, slightly reflexed ventral margin, arcuate-truncate; labrum projecting; malar space subequal to basal width of mandible; mandible 1.6 times as long as basal width; occipital carina complete, joining hypostomal carina about basal width of mandible from mandible; antenna 0.7 as long as body, flagellum 31-segmented, first flagellar segment 6 times as long as wide, second segment slightly shorter, third 0.6 as long as first.

Pronotum finely punctate-rugulose, with distinct epomia; mesoscutum finely and densely punctate, subpolished; notaulices deeply impressed, extending posteriorly to a line tangential to posterior margin of tegulae; scutellar fovea longitudinally rugose; scutellum polished and densely punctate; prepectoral carina incomplete, extending 0.7 distance to subalar tubercle; sternaulus complete, deeply impressed, especially anteriorly, subfoveolate; mesopleura, metapleura, and propodeum finely, reticulately, rugulose-punctate; speculum slightly elevated, polished, moderately punctate; propodeum with basal transverse carina weak, but present; apical transverse carina strong, especially on lateral angles; propodeal spiracle twice as long as wide.

Coxae polished, finely and densely punctate, with short, somewhat appressed pubescence; hind femur 5 times as long as high; hind tibia 1.3 times as long as hind femur, longer hind tibial spur 0.4 as long as first segment of hind tarsus; anterior tibia in female strongly and convexly swollen from basal fourth almost to tip; tarsi normal; claw small, with fine pectination and bristles at base, but no strong, terminal tooth in pecten.

Areolet strongly anteriorly convergent, first intercubitus slightly reclivous, second intercubitus strongly inclivous, anterior side of areolet subequal to first abscissa of cubitus; second recurrent vein received beyond middle of areolet; ramellus present; nervulus antefurcal.

Abdomen coriaceous; petiole depressed and polished dorsally, transversely rugulose laterally, postpetiole 3 times as wide as petiole, dorsal carinae present, but not strongly elevated; second tergite twice as wide at posterior margin as at base, as long as basal width; third tergite 1.7 times as wide as long; follow-

ing tergites transverse, successively narrower and shorter; ovipositor compressed, sagittate, sheaths of ovipositor slightly longer than abdomen.

Black; abdomen entirely, and legs below trochanters reddish-ferruginous, apices of hind tibiae and most of tarsi somewhat obfuscated; labrum and basal flagellar segments piceous; an incomplete, pale annulus on flagellar segments 5-8, following flagellar segments fuscous; orbits entirely encircling eyes except posterior to malar space and behind top of eye, pale yellowish-white; wings hyaline tinged with fuscous; stigma and veins brownish.

Male.—Very similar to female, differing from previous description of female as follows: face twice as wide as high, flagellum 33-segmented; epomia weaker; dorsal portion of pronotum longitudinally striate between epomiae; basal transverse carina of propodeum about as strong as apical transverse carina, and apical carina not at all produced laterally; anterior tibiae normal; abdomen and postpetiole more slender; subgenital plate and genitalia (fig. 71).

Black; abdominal tergites 1-4 entirely and base of tergite 5 and legs beyond trochanters ferruginous or reddish; tips of hind tibiae and hind tarsi entirely infuscated; face entirely, clypeus, labrum, mandible except teeth, orbits encircling eyes except behind malar space, scape beneath, spots on anterior and middle coxae and trochanters, lines on posterior lateral margin of pronotum, tegulae, and subalar tubercle yellowish-white.

Holotype.—Female, Kaslo, British Columbia, June 13, H. G. Dyar, Cat. No. 55432, U. S. National Museum, Washington, D. C.

Allotype.—Male, Chilcotin, British Columbia, June 3, 1929, G. J. Spencer, in Canadian National Collection, Ottawa, Canada.

Paratypes.—BRITISH COLUMBIA: Big Bend Country in Selkirk Mts., Chilcotin, Vernon; MANITOBA: Aweme; MONTANA: Big Fork, Bozeman, Gallatin Valley, Culbertson, Missoula; SOUTH DAKOTA: White Lake. Collections made during May, June, July, and August. Specimens in USNM, CN, CU, BC, MU, MONT. SD.

Remarks.—Very variable in amount of white markings in male. Sometimes scutellum and a spot in front of the tegula are white; the orbits may be complete, or interrupted behind malar space and behind top of eye; the first tergite and abdomen beyond fourth tergite may be entirely reddish or black, but tergites 2-4 are always entirely reddish. The females are more constant in coloration than the males. The first tergite is usually entirely or largely reddish, and this is a character of some importance in separating the species from *persimilis*. The number of flagellar segments varies from 29-33.

Cryptus mutatus, new species

Fig. 72

Female.—Length 9 mm., ovipositor 3.5 mm.

Head coriaceous, subpolished, densely clothed with more or less appressed, short, silvery-white pubescence; genae minutely and densely punctate, sharply and convexly narrowed behind eyes; occiput deeply concave; ocell-ocular line 1.4 times as long as diameter of lateral ocellus, post-ocellar line twice as long as diameter of lateral ocellus; frons moderately excavated, without a vertical ridge behind each antennal foramen; face twice as wide as high, with a promi-

nent median elevation; clypeus convex, with a slightly reflexed, highly polished margin; labrum projecting; malar space subequal to basal width of mandible; mandible 1.5 times as long as basal width; antenna 0.8 as long as body, flagellum 39-segmented, first flagellar segment 6.5 times as long as wide, second 0.7 as long as first, third about 0.5 as long as first.

Thorax densely clothed with short, somewhat appressed, silvery-white pubescence; pronotum with a prominent epomia curving anteriorly; lateral portion of pronotum punctate above, irregularly transversely rugulose below; mesoscutum shining, densely and finely punctate; notaulices strong, minutely foveolate, extending posteriorly to a line tangential to posterior margin of tegulae; scutellar fovea longitudinally striate; scutellum slightly margined at base, convex, subpolished, very minutely punctate; prepectoral carina complete, extending to subalar tubercle; sternaulus complete; mesopleura, metapleura, and propodeum reticulately rugulose; speculum slightly elevated, polished, moderately punctate; propodeum with two transverse carinae, posterior carina stronger than basal and slightly produced laterally, propodeal spiracle twice as long as wide.

Legs rather slender, coxae densely and finely punctate, and, like the rest of the legs, with short, silvery-white pubescence; femur 5 times as long as high; hind tibia 1.3 times longer than hind femur, longer spur of hind tibia 0.4 as long as first segment of hind tarsus; anterior tibia increasing in diameter very gradually from basal fourth to tip; tarsi normal; claws simply pectinate at base.

Areolet strongly convergent anteriorly, first intercubitus reclivous, second intercubitus inclivous, anterior side 0.3 as long as first intercubitus; second recurrent vein straight on posterior half, distinctly curved on anterior half, received beyond middle of areolet; ramellus conspicuous.

Abdomen moderately stout, finely coriaceous, subpolished; petiole of first tergite depressed, weakly transversely rugulose laterally, postpetiole 3 times as wide as petiole; dorsal carinae weak, fading out opposite spiracles; second tergite 0.7 as long as width of posterior margin, posterior margin twice as wide as postpetiole; third tergite 1.5 times as broad as long, about as long as second tergite; following tergites transverse, successively shorter and narrower; ovipositor sagittate, sheaths of ovipositor as long as tergites 2-6.

Black; abdomen except basal fourth of first tergite, all femora, fore and middle tibiae and tarsi more or less reddish-ferruginous; hind tibiae and tarsi darker ferruginous; narrow lines on posterior and facial orbits, dot opposite top of eye, dot on clypeus and labrum, yellowish-white.

Male.—Differs from preceding description of female as follows: malar space 0.8 as long as basal width of mandible; flagellum 36-segmented; propodeum evenly convex, basal transverse carina about as strong as apical transverse carina; abdomen much more slender, sternite of first segment extending posteriorly beyond spiracle; subgenital plate and genitalia (fig. 72).

Black; hind femora and abdomen reddish-ferruginous; narrow line on posterior orbits, broad anterior orbits, line opposite top of eye, median elevation of face, most of clypeus and labrum, and mandible except base and teeth, palpi, tegulae, subalar tubercle, spots on anterior and middle coxae and tro-

chanters, and segments 2-4 of hind tarsus, white; line on anterior and middle femora, most of anterior and middle tibiae and tarsi ferruginous; hind tibia and first segment of hind tarsus, black.

Holotype.—Female, Crater Lake Park, Oregon, Sun Creek Meadows, 6500-7000 ft., August 26, 1930, H. A. Scullen, Cat. No. 55434, U. S. National Museum, Washington, D. C.

Allotype.—Male. Mt. Rainier, Washington, 5300 ft., August 17, 1940, H. & M. Townes, in collection Dr. H. K. Townes.

Paratypes.—BRITISH COLUMBIA: Kaslo, Oliver; CALIFORNIA: Gold Lake in Sierra County, Mt. Tallac near Tahoe; COLORADO: "Colorado," Troublesome; IDAHO: Moscow; NEVADA: "Nevada"; OREGON: Mt. Hood, Lake Wallewa, Cornucopia; WASHINGTON: Pullman, Summit Mt. Spokane, Mt. Ranier; WYOMING: Medicine Bow. Collections made in June, July, and August. Specimens in USNM, CN, CAS, AES, OR, W, MU, AMNH, TOW.

Remarks.—This species is apparently found most commonly at high elevations in western North America. The female is best distinguished by the ovipositor which is as long as tergites 2-6 or 2-8, and by the form of the anterior tibia. The male is remarkable in having conspicuously white segments 2-4 in the hind tarsi, whereas these segments are concolorous with the rest of the tarsus and tips of hind tibia in *persimilis, associatus,* and *atritibialis.*

Cryptus atritibialis, new species

Figs. 48, 73

Female.—Length 11 mm., ovipositor 7 mm.

Head with short, silvery-white pubescence; genae slightly narrowed behind eyes, strongly convex; occiput deeply concave; post-ocellar line subequal to ocell-ocular line, 1.7 times longer than diameter of lateral ocellus; eyes subparallel; frons shallowly excavated, without a ridge behind each antennal foramen, rugulose-punctate; face 2.2 times as wide as high, with a prominent median elevation; clypeus convex, with narrow, slightly reflexed, apical margin; labrum projecting; malar space subequal to basal width of mandible; mandible 1.5 times as long as basal width, teeth subequal; occipital carina complete, joining hypostomal carina about 0.7 basal width of mandible from mandible; antenna 0.8 as long as body, flagellum 37-segmented, basal segment 6 times as long as wide, second segment 5 times as long as wide, third 4 times as long as wide.

Pronotum with mere trace of epomia, rugulose-punctate throughout; mesoscutum subpolished, densely punctate; notaulices deeply impressed, extending posteriorly to a line tangential to posterior margins of tegulae; scutellar fovea longitudinally striate; scutellum convex, moderately punctate, subpolished, sloping to apex; prepectoral carina weak, but extending to subalar tubercle; sternaulus not deeply impressed, very weak posteriorly and incomplete; mesopleura, metapleura, and propodeum rugulose-punctate; speculum elevated, polished, impunctate; propodeum with apical carina weak, interrupted medially, basal carina merely indicated; propodeal spiracle 1.6 times as long as wide.

Legs long and slender, hind coxae densely punctate, subpolished, with short, somewhat appressed whitish pubescence; hind femur 5 times as long as high;

hind tibia 1.2 times longer than hind femur; longer hind tibial spur about 0.3 as long as first segment of hind tarsus; fore tibia increasing gradually in diameter from basal fourth to tip (fig. 48); tarsi normal; claw small, not as long as third tarsal segment, weakly pectinate at base.

Areolet strongly anteriorly convergent, first intercubitus strongly reclivous, second intercubitus strongly inclivous, anterior side shorter than either abscissa of cubitus; second recurrent vein straight on posterior half, distinctly curved on anterior half, received beyond middle of areolet; ramellus present.

Abdomen finely coriaceous; first tergite distinctly bent just before spiracle, petiole depressed, laterally coarsely punctate and transversely rugulose, postpetiole 3 times as wide as petiole, dorsal carinae prominent; second tergite 1.5 times as wide at posterior margin as long; third tergite 0.8 as long as wide; ovipositor sagittate; sheaths of oviposiitor as long as abdomen.

Black; middle and hind femora except extreme tips and abdomen except basal part of first tergite reddish-ferruginous; anterior legs below trochanters and middle tibiae and tarsi rufo-piceous; narrow lines on anterior and posterior orbits, and line opposite top of eye, yellowish-white; wings dark fuscous, veins and stigma piceous.

Holotype.—Female, Almogordo, New Mexico, June 25, 1902, probably collected by H. L. Viereck or J. A. G. Rehn, in the Academy of Natural Sciences, Philadelphia, Pa.

Allotype.—Male, Jackson, Wyoming, July 13-17, 1920, 6300 ft., in American Museum of Natural History, New York.

Paratypes.—1 female, Bozeman, Montana, Elevation 4800 feet, July 8, 1902 (MONT); 1 female, Almogordo, New Mexico, April 25, 1902, probably collected by H. L. Viereck or J. A. G. Rehn (MU).

Remarks.—Similar superficially to *persimilis* but the hind tibia is uniformly darker, and the female is at once distinguished by the longer ovipositor and sheaths, form of anterior tibia, and much larger size.

Cryptus ruralis, new species

Female.—Length 10 mm., ovipositor 7 mm.

Differs from *atritibialis* as follows: genae much narrower opposite dorsal margin of eye than opposite ventral margin; face twice as wide as high; malar space 0.8 as long as basal width of mandible; flagellum 36-segmented, basal segment 7 times as long as wide, second 0.8 and third 0.7 as long as first; pronotum finely rugulose-punctate, epomia strong; prepectoral carina incomplete, extending 0.6 distance to subalar tubercle; sternaulus deeply impressed, complete; propodeum with apical transverse carina weak, but complete; propodeal spiracle 2.5 times as long as wide; hind femur 6 times as long as high; hind tibia 1.4 times as long as hind femur; first tergite slightly decurved, not conspicuously bent as in *atritibialis;* second tergite with posterior margin twice as wide as base, 1.7 times as long as basal width; third tergite 1.7 times as wide as long; sheath of ovipositor 1.5 times as long as abdomen.

Black; abdomen and hind femora reddish-ferruginous; narrow lines on

anterior and posterior orbits, and on vertex opposite top of eye, spot in middle of clypeus, lines on dorso-lateral margin of pronotum just anterior to notaulices, spot in front of tegula, and subalar tubercle white; tibia and tarsi and middle portion of mandible piceous.

Holotype.—Female (Va Dale) Virginia Dale, Colorado, August 15, 1903, Cat. No. 55438, U. S. National Museum, Washington, D. C.

Paratype.—1 female, Lethbridge, Alberta, July 16, 1913, E. H. Strickland (CN). The label bears a large "L," which Strickland (in litt.) writes indicates that the specimen was taken at light.

zoesmairia Dalla Torre [*Cryptus*]. Cryptini.
Hoplocryptus zoesmairia (Dalla Torre)

zonata Cushman [*Polistiphaga*]. Phygadeuonini.
Polistiphaga zonata Cushman. Ref. Cushman (1929: 57).

Index

For synonymy of the more than 200 species of Nearctic Ichneumonidae which have been referred to the genus *Cryptus* at one time or another the reader is referred to H. K. Townes, *A catalogue and classification of the Nearctic Ichneumonidae*, Memoirs of the American Entomological Society, No. 11, pt. I, 1944; pt. II, 1945.

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leucopus 592
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EXPLANATION OF PLATES

In this explanation, two new nomenclatorial combinations appear, **Hidryta frater** (fig. 20), and **Hoplocryptus imitator** (fig. 28). The original descriptions of these are as follows: *Cryptus frater* Cresson, 1864, Proc. Ent. Soc. Phil., 3:303, no. 19, female. *Cryptus imitator* Provancher, 1877, Nat. Can., 9:13, female.

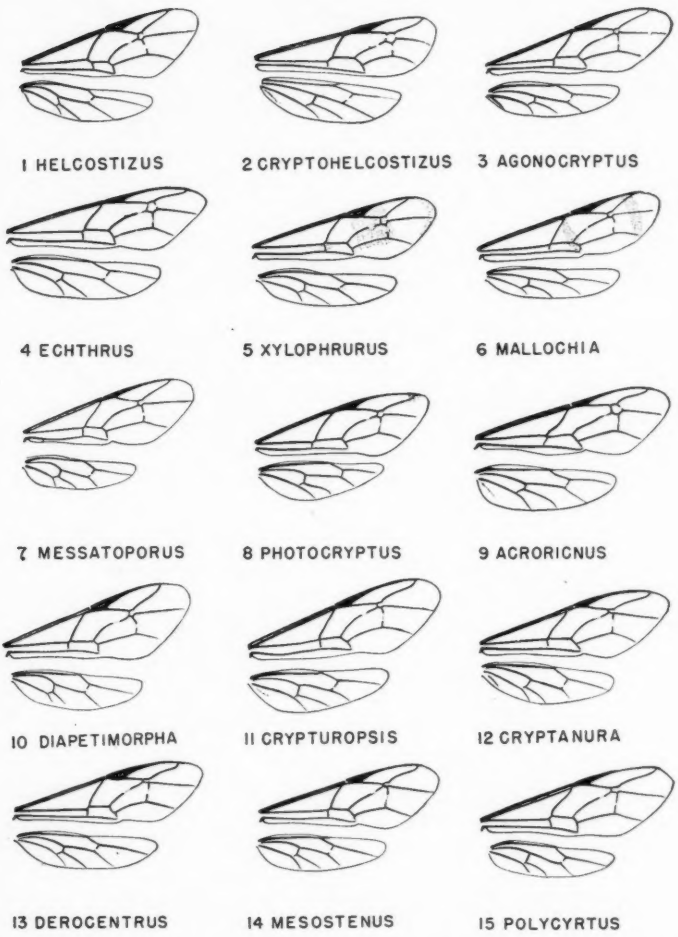


PLATE 1.—Figs. 1-15. Fore and Hind Wings. 1, *Helcostizus albator* (Thunberg). 2, *Cryptohelcostizus dichrous* Viereck. 3, *Agonocryptus discoidaloides* (Viereck). 4, *Echthrus niger* Cresson. 5, *Xylophrurus* nr. *fasciatus* (Ashmead). 6, *Mallochia agenioides* Viereck. 7, *Messatoporus discoidalis* (Cresson). 8, *Photocryptus pachymenae* (Cresson). 9, *Acroricnus aequatus junceus* (Cresson). 10, *Diapetimorpha orba* (Say). 11, *Crypturopsis audax* (Cresson). 12, *Cryptanura spinaria* (Brullé). 13, *Derocentrus macilentus* (Cresson). 14, *Mesostenus thoracicus* Cresson. 15, *Polycryptus neglectus* Cushman.

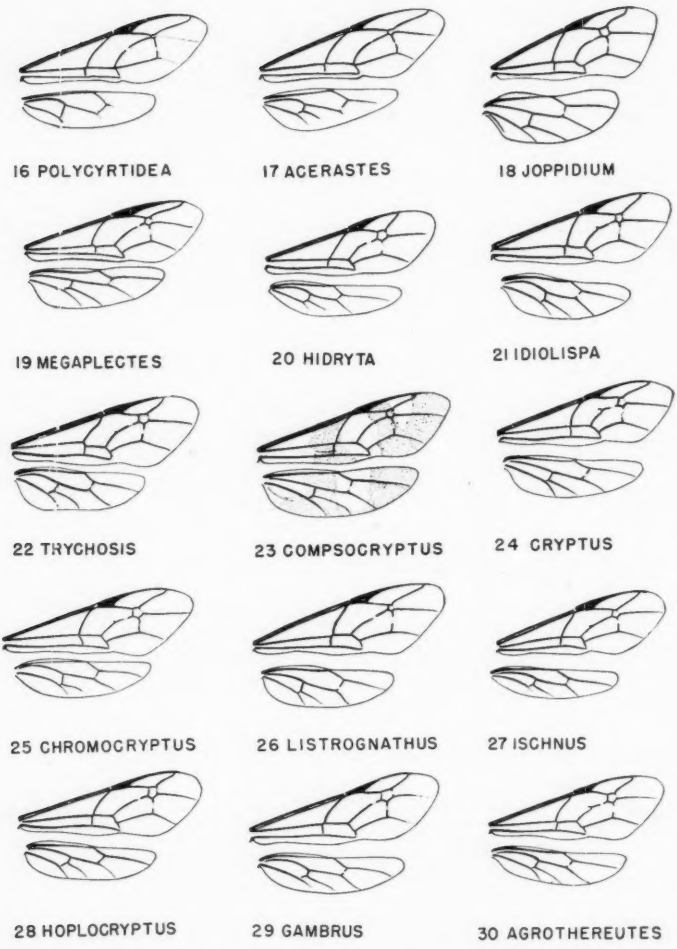


PLATE 2.—Figs. 16-30, Fore and Hind Wings. 16, *Polycyrtidea pusilla* (Cresson). 17, *Acerastes pertinax* (Cresson). 18, *Joppidium apicale* Cresson. 19, *Megaplectes blakei* (Cresson). 20, *Hidryta frater* (Cresson). 21, *Idiolispa limata* (Cresson). 22, *Trychosis* sp. 23, *Compsocryptus calipterus* (Say). 24, *Cryptus persimilis* Cresson. 25, *Chromocryptus planosae* (Fitch). 26, *Listrognathus albomaculatus* (Cresson). 27, *Ischnus exilis* Provancher. 28, *Hoplocryptus imitator* (Provancher). 29, *Gambrus extrematis* (Cresson). 30, *Agrothereutes* sp.

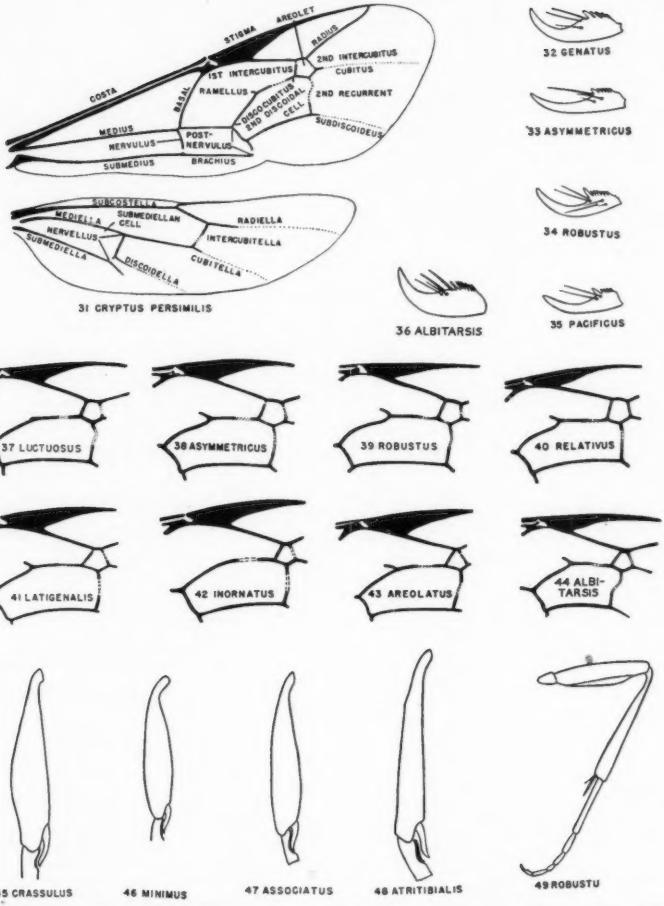


PLATE 3.—Figs. 31-49. 31, *Cryptus persimilis* Cresson, fore and hind wings. 32, *C. genatus* Pratt, claw of fore leg, female. 33, *C. asymmetricus* Pratt, claw of hind leg, female. 34. *C. robustus* Cresson, claw of hind leg, female. 35, *C. pacificus* Cresson, claw of hind leg, female. 36, *C. a. albitarsis* (Cresson), claw of hind leg, female. 37, *C. luctuosus* Cresson, areolet and part of fore wing. 38, *C. asymmetricus* Pratt, areolet and part of fore wing. 39, *C. robustus* Cresson, areolet and part of fore wing. 40, *C. relativus* Cresson, areolet and part of fore wing. 41, *C. latigenalis* Pratt, areolet and part of fore wing. 42, *C. inornatus* Pratt, areolet and part of fore wing. 43, *C. areolatus* Pratt, areolet and part of fore wing. 44, *C. a. albitarsis* (Cresson), areolet and part of fore wing. 45, *C. crassulus* Pratt, right anterior tibia of female. 46, *C. minimus* Pratt, right anterior tibia of female. 47, *C. associatus* Pratt, right anterior tibia of female. 48, *C. atritibialis* Pratt, right anterior tibia of female. 49, *C. robustus* Cresson, trochantella, femur, tibia and tarsus of hind leg of female.

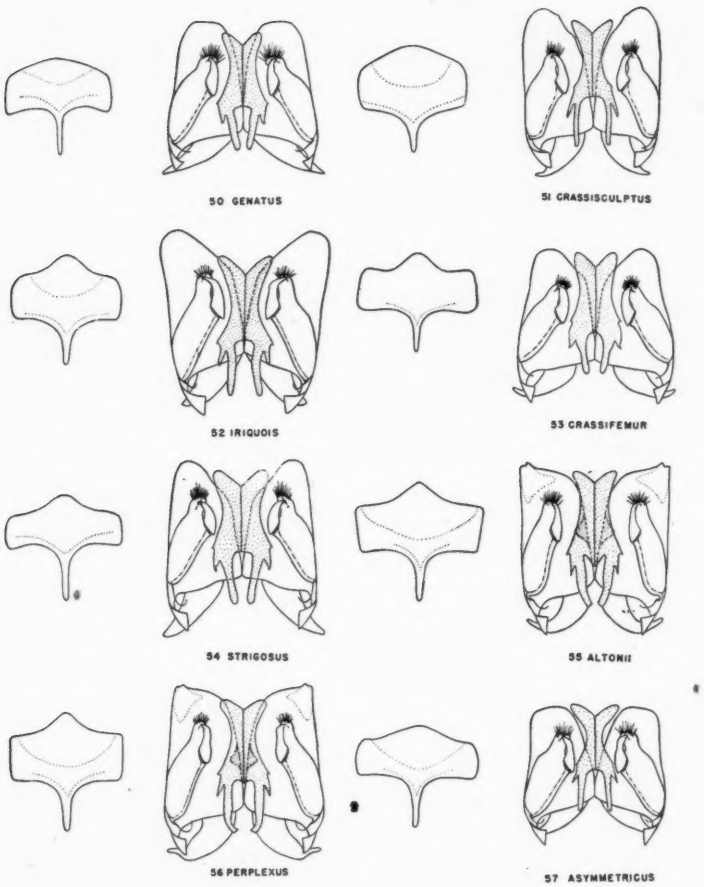
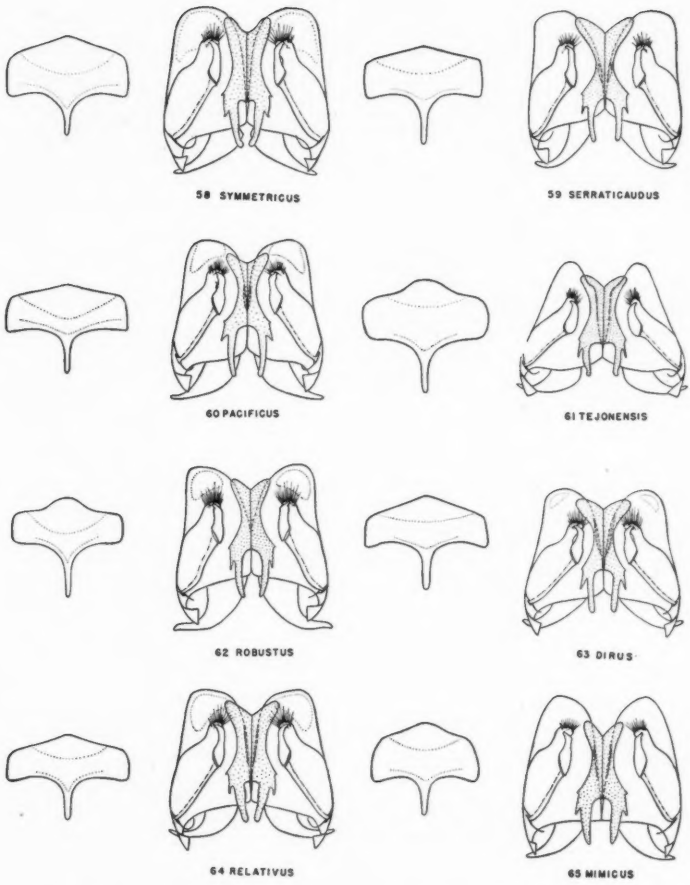


PLATE 4.—Figs. 50-57. Subgenital plate and male genitalia. 50. *Cryptus genatus* Pratt. 51, *Cryptus crassisculptus* Pratt. 52, *Cryptus iriquois* (Viereck). 53, *Cryptus crassifemur* Pratt. 54, *Cryptus strigosus* Pratt. 55, *Cryptus altonii* Dalla Torre. 56, *Cryptus perplexus* Cresson. 57, *Cryptus asymmetricus* Pratt.



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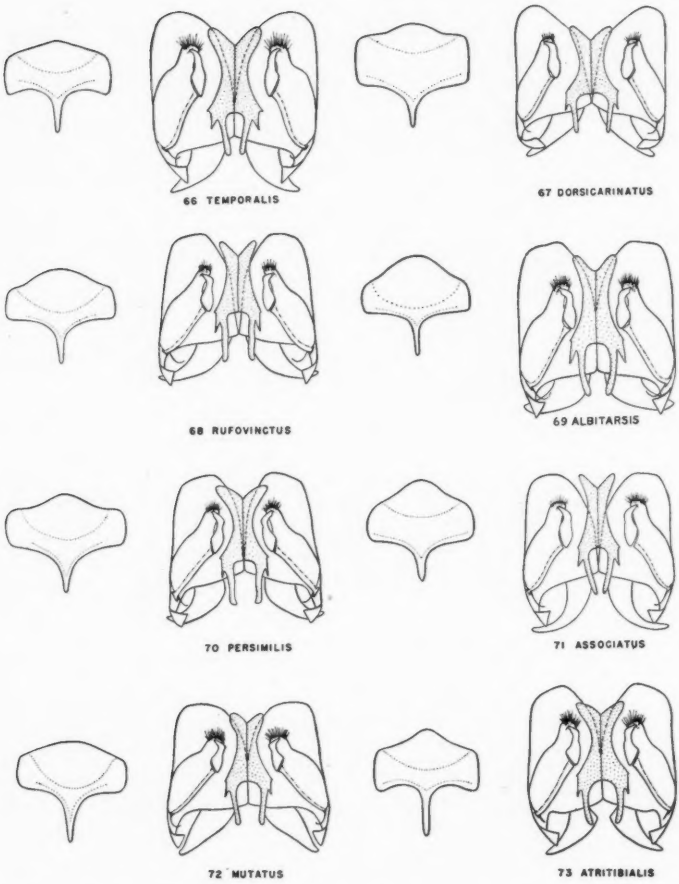

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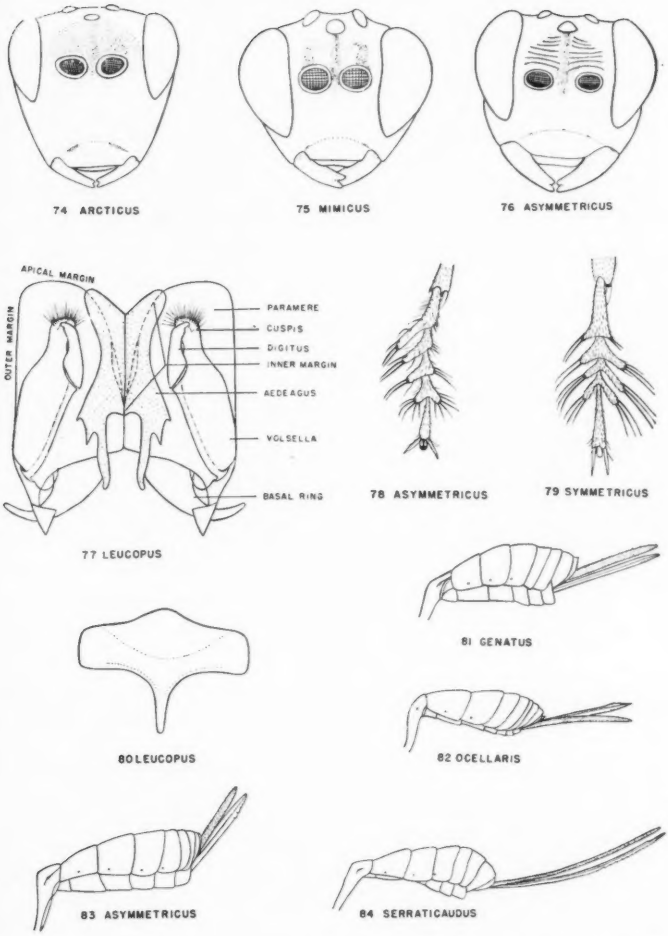

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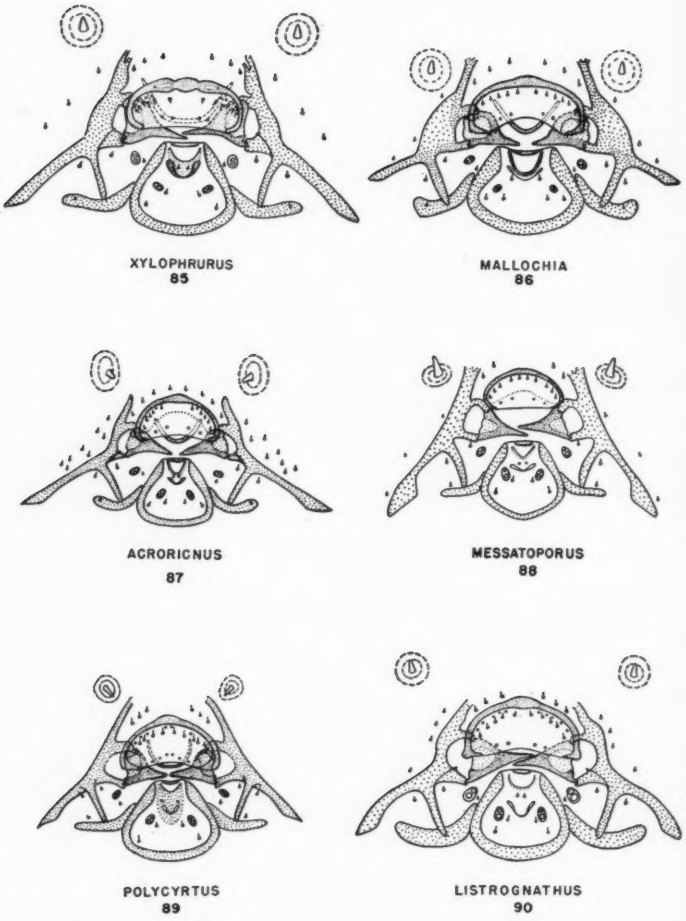

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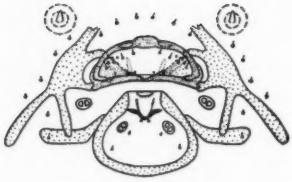

DIAPETIMORPHA
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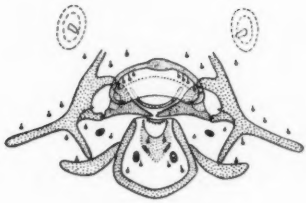

CRYPTUROPSIS
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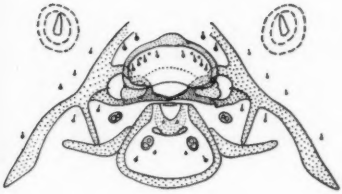

MESOSTENUS
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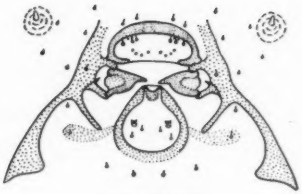

ACERASTES
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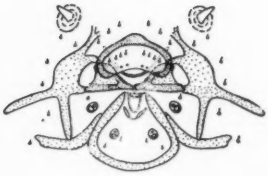

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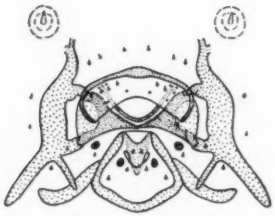

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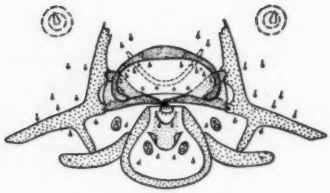

CHROMOCRYPTUS
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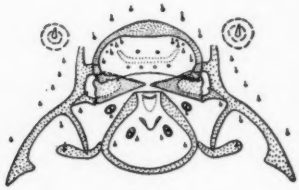

ISCHNUS
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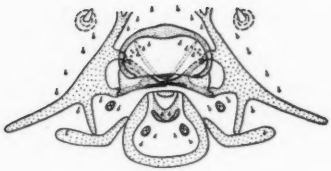

AGROTHEREUTES
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HOPLOCRYPTUS
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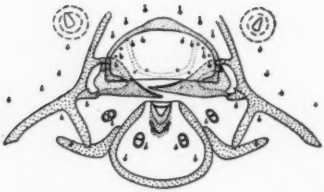

GAMBRUS
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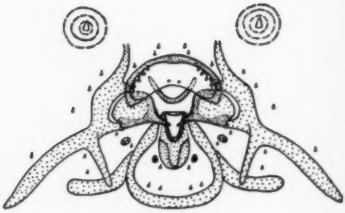

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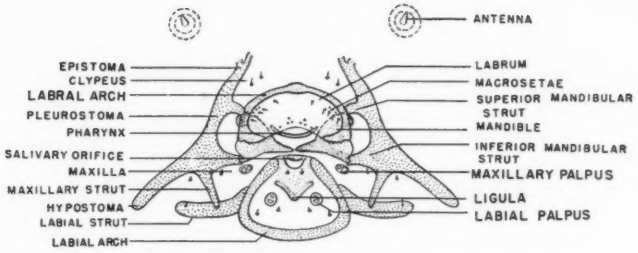
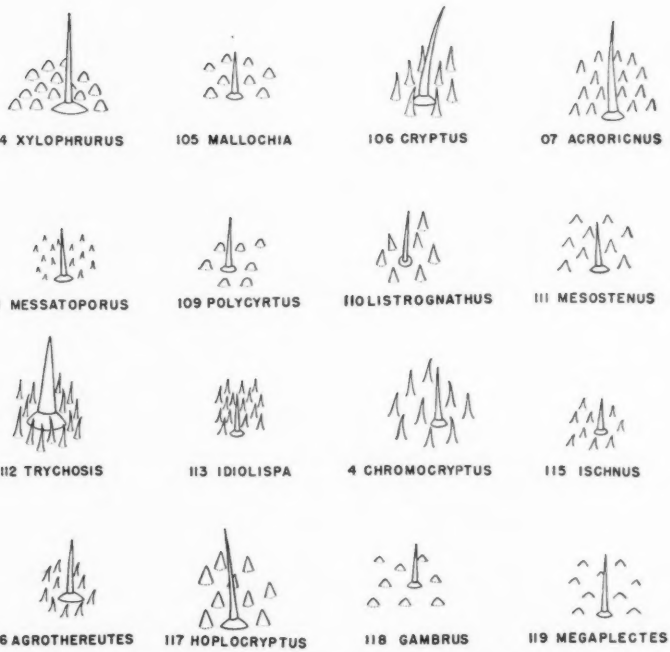


103 CRYPTUS ALBITARSIS



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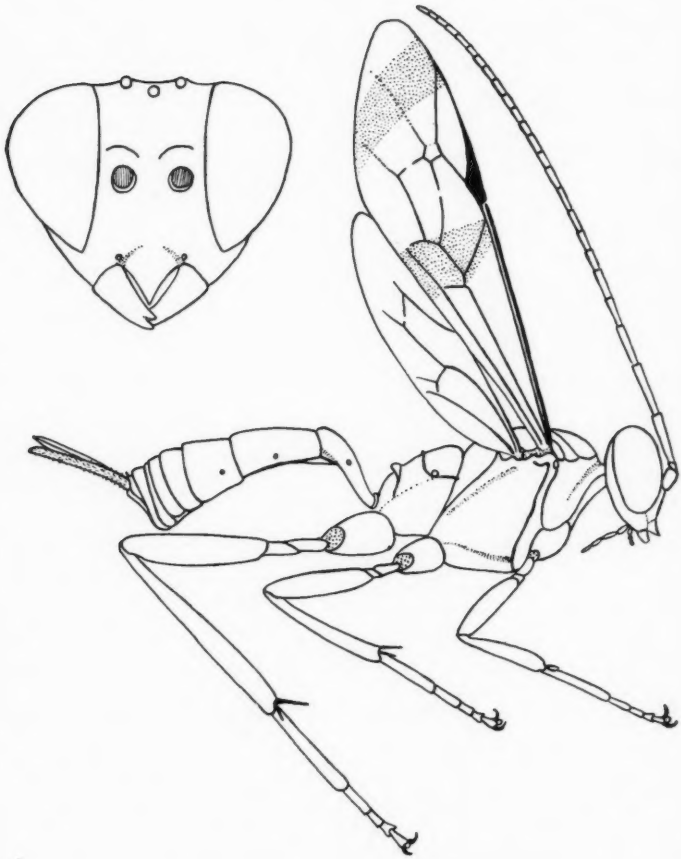

PLATE 12.—*Nasutocryptus nasutus* Pratt, head in frontal aspect and lateral view of entire insect.

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On the Ability of the Caterpillars of the Milkweed-Moth, Euchaetias egle Drury, to Land on the Feet After Falling[1]

Hubert Frings

Introduction

The ability of the cat to land on its feet when falling is a matter of common knowledge. It is not so well known, however, that wolf-spiders (Arachnida, Lycosidae) and certain caterpillars (Insecta, Lepidoptera) likewise have this ability. Buddenbrock and Friedrich,[2] for instance, in their excellent study of fall-reflexes in certain Arthropods, did not investigate these forms. While I have had ample opportunity to observe this in many species of wolf-spiders, I have not been able to devise critical experiments to study this phenomenon in these forms. However, during the past summer I had access to a sufficient number of caterpillars of the milkweed-moth, *Euchaetias egle* Drury (Family, Arctiidae), to study the mechanism of landing on the feet in this form. The following paper records the results of this study.

General Experimental Methods

The caterpillars used in this work were in the next to last or last larval instars. They were brought to the laboratory and kept in groups of variable numbers in glass jars where they were supplied with fresh leaves of milkweed (*Asclepias*) as needed. For experimentation they were removed from the culture-jars and tested on an open laboratory table. The apparatus used in the tests and the specific methods used for each will be given in detail in the section on experiments. Generally the larvae feigned death for a short time after removal from the jar, but this did not last long, and, after they had started crawling again, they proved to be satisfactory subjects. All the experiments were performed with ordinary daylight entering a window as the source of illumination and at a temperature of 23° C.

Description of the Larva

Since, as will be shown below, the possession of certain sets of body-hairs is an important factor in the ability of these caterpillars to land on the feet, a brief discussion of the general external anatomy and arrangement

1 It is a pleasure to express my appreciation to Mr. Carl Heinrich, of the U.S. National Museum, for his kindness in arranging for the photographs reproduced in fig. 1, and to Miss Elizabeth Dailey, a student at this institution, for collecting many of the caterpillars used in this work and for finding milkweed plants on which they were abundant.

2 Buddenbrock, W. v. and H. Friedrich. 1932—Ueber Fallreflexe von Arthropoden. Zool. Jahrb., Abt. Zool. Physiol. **51**:131-148.

of body-hairs is in order. This is not to be interpreted as an attempt to map all the body-hairs or to redescribe the chaetotaxy of this form, for the interest here is mainly in those groups which the experiments showed to be important.

Fig. 1 shows the general external anatomy of this animal. It is obvious that the dense coat of body-hairs is responsible for the major contours. This is especially applicable if the larva is contracted longitudinally. There

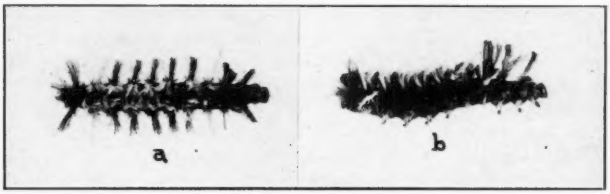


Fig. 1. Dorsal (a) and lateral (b) views of the larva of *Euchaetias egle*. This is an inflated dried specimen, slightly more expanded longitudinally than the living animal except when it is in an extended form. (Photographs courtesy of the U. S. National Museum).

are two sets of hairs which were found to be of great importance in the ability of this form to land on the feet—the dorsal arch of orange and white hairs on abdominal segments 1 to 7, and the laterally extending hairs on the same segments. Two other sets of lesser importance are: first, the set of long black hairs arising from the two dorsalmost setiferous tubercles on each side of thoracic segments 2 and 3 which extend upward and forward over the head and conceal it from the dorsal aspect when it is withdrawn, and second, a corresponding set from the two dorsalmost setiferous tubercles

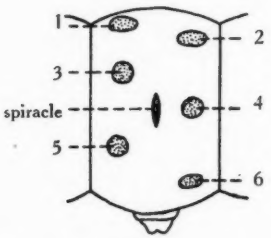


Fig. 2. Diagram showing the arrangement of the main setiferous tubercles on the body wall of an abdominal segment of the caterpillar of *Euchaetias egle*.

on abdominal segments 8 and 9 which extend upward and backward and conceal the anal legs.

Fig. 2 is a diagram showing the arrangement of setifercus tubercles on an abdominal segment. The dorsal orange and white hairs on abdominal segments 2 to 6 arise from tubercles I and II, the orange from I and the white from II. These curve in toward the middorsal line, meeting there and

forming an arch which is in depth about 3/4 of the depth of the body proper. Abdominal segment 1 has the white hairs of the dorsal arch from tubercle II, but, in place of the orange hairs from tubercle I, it has a pair of black tufts extending straight upward about twice the height of the dorsal arch. Abdominal segment 7 has the dorsal arch composed of white and black hairs, arising from tubercles I and II. The lateral tufts arise from tubercle III; those on abdominal segments 2 to 6 are black and extend outward, with a slight upward sweep, a little over 1/2 the width of the body proper, and those on abdominal segments 1 and 7 are white and extend outward about as far as the body width. The other tubercles bear shorter hairs which produce a rounded contour and are of no specific importance for this study. The arrangement of hairs of significance here on abdominal segments 8 and 9 has been described above.

There are two types of hairs arising from the setiferous tubercles. One type is relatively short, stiff, and spine-like in appearance, these hairs forming whorls near the body-wall; the other type is long, pliable, of a loosely

Fig. 3. Terminal portion of hair of *Euchaetias egle* (highly magnified).

feathery appearance (fig. 3), forming the tufts. The two types do not seem to be distinct, for they are similar in general structure and intermediate forms are found between the two extremes. The short spines are usually black in color and give the body a generally dark appearance, while the tufts are orange, black, or white, as described above. An interesting modification is found on tubercles I and II of abdominal segments 2 to 7, where those black hairs of the basal whorl which arise near the middorsal line are longer than the other hairs found in the basal whorls and are curved in under the white and orange hairs to make the dorsal arch of hairs extremely compact.

Experiments and Results

EXPERIMENTS WITH NORMAL CATERPILLARS

When disturbed on the leaves of the food plant, where they are usually found on the under sides, these larvae drop spontaneously. This often causes them simply to land on leaves lower down, but usually they strike these without taking hold and fall to the ground. Study of the ability to land on the feet is thus complicated under natural conditions, but it can easily be seen if the milkweed plants are removed to a cleared area and the larvae disturbed. The interesting thing first noted in this was that the larvae managed to land upright in a large percentage of cases, even after ricocheting from a leaf after falling. Many, however, after striking a leaf in falling curled up and feigned death, thus masking any righting response. Solving the problem of how these caterpillars managed to land on the feet after falling under natural conditions thus proved impossible.

Two methods of experimentation were, therefore, developed and were used in this study. In one, a larva was allowed to crawl upside down on a glass rod (3 mm. diameter) held at various heights above the laboratory table until it dropped off. In the second method, a caterpillar was dropped from forceps, so that it could be released in different positions: head downward, head upward, right side up, or upside down. The dense coat of hairs on the caterpillar made it simple to hold it with forceps without injury.

On the glass rod, a normal larva ordinarily would crawl back and forth dorsal side down until it released spontaneously. Dropping off occurred most often at the end of the rod, after the larva had crawled out until just the third and fourth pairs of prolegs and the anal legs [3] were still holding to the rod. It was not forced at this point, however, because often, after exploring the space beyond the end of the rod with the anterior end of the body, the larva would loop back, take hold of the rod with the thoracic legs, and reverse direction, creeping to the other end of the rod. Thus dropping was truly spontaneous, the impulse that brought it about seeming to be of internal origin, for it was impossible to predict whether any animal or even the same animal at different times would reverse direction or would drop. Jarring or shaking of the rod would not appear to be the cause, for, when I wanted a larva to drop, simple jarring did not cause it to release itself from the glass rod. Only one effective way was found to cause a larva to release itself and that was to heat a section toward which it was creeping. This was used in some cases to hasten the dropping so that experimentation could be expedited. The caterpillars did not release only at the ends of the rod; sometimes they would drop from some spot along the rod. Almost invariably when this was done the animals would first release all but the last two pairs of prolegs and the anal legs, just as they did at the ends of the rod. This, however, was not the only pre-drop position, for the larvae sometimes released all but the anal legs and fell away to perfect landings. In a few cases, larvae were taken up with just the thoracic legs holding the rod, and they released themselves to make perfect landings.

Observing normal caterpillars (46 individuals, variable numbers of trials with each) dropping spontaneously from a glass rod, the following facts about the ability to land on the feet were noted. The caterpillars turned end for end in dropping; thus, if a larva were facing toward the left on the rod, it landed on the table facing right. This was not always perfect, but the slight shifts to the sides could easily be caused by release of some of the legs before the others. The larvae dropped from heights of 10 cm., 20 cm., 30 cm., 40 cm., 50 cm., 60 cm., and 100 cm., releasing spontaneously at any of these heights and landing in all cases upright, almost always facing in reverse direction from that in which they were facing when they released themselves. At 5 cm., 4 cm., and 3 cm. from the table top, the larvae exe-

[3] The number and position of legs in this species is that typical of most lepidopterous larvae—one pair of legs on each of the thoracic segments, four pairs of prolegs on abdominal segments 3, 4, 5, and 6, and a pair of anal legs on abdominal segment 10.

cuted perfect landings, turning end for end. At 2 cm., the larvae tended to land slightly head first, and the landings were not quite so perfect as higher. Below 2 cm., the larvae could reach the table by stretching down to it, and they simply crawled off. Thus, the upright position seems to be assumed within the first 2 cm. after dropping. There were no obvious shifts while falling, the larvae seeming to remain upright as they were after the first few centimeters of fall. To test this accurately, since the total time in the air at all heights used was well below one second, larvae (10 individuals) were allowed to drop from 50 cm. and a piece of paper was thrust into the line of fall just as they released themselves. The paper could be inserted at 40 cm., 30 cm., 20 cm., or 10 cm. without disturbing the ability of the animals to land on the feet perfectly when dropping from 50 cm. Other heights were similarly tested, with comparable results. Apparently, the phase of righting over which the larva has control in landing on the feet is completed as the larva leaves the rod or within a few centimeters of fall.

Caterpillars (36 individuals, variable numbers of trials with each) held in the forceps and dropped with the dorsal side upward landed on the feet regardless of the height. When held head upward, a larva bent the anterior end of the body slightly ventralward and the posterior end slightly dorsalward, producing a sigmoid shape. When held head downward, the anterior end of the body was bent slightly dorsalward and the posterior end slightly ventralward, forming a similar sigmoid shape. Falling from these positions, larvae landed well at all heights above 5 cm., but landed imperfectly below that, tending to strike head first or head up and to roll somewhat to an upright position. When dropped upside down or in a sidewise position, the landings were not perfect. While not usually landing upside down, the caterpillars struck other than exactly upright and came onto the feet after a slight roll. Especially from heights below 30 cm., the landings were imperfect; above this, more perfect landings were achieved. It is interesting to compare the results with caterpillars released from forceps upside down with those obtained when these same caterpillars released themselves spontaneously from an upside down position. In the latter case, they landed perfectly on the feet, while, in the former, especially at heights of only 20 or 30 cm., they landed sidewise and rolled to an upright stance.

As a general observation in all these cases, it was noted that the caterpillars always landed in a longitudinally contracted position, although they often released themselves markedly extended. The assumption of the contracted state apparently took place immediately upon losing contact, for they were contracted when they landed on sheets of paper inserted 10 cm. below them after falling, and they landed in the contracted form even when falling from only 3 cm.

EXPERIMENTS WITH DEAD AND ANAESTHETIZED LARVAE

To determine in how far the physical structure of the body in this species brought about landing on the feet, experiments were performed with dead caterpillars and with caterpillars which were anaesthetized with ether. The

dead caterpillars were preserved in alcohol; for experimentation, they were dried in the air until the hairs appeared normal. They were stiff, straight, and somewhat more extended longitudinally than ordinary falling animals.

The first discovery made with these dead and anaesthetized specimens was that there are really only three possible positions in which they can land, and this applies to normal larvae as well. The first of these positions is the upright position. The second is a semi-upright position, with the laterally projecting hairs on one side touching the substrate and the animal resting on the legs and hairs of that side. The third position is a semi-supine position, with the animal resting on the dorsal arch of hairs and the lateral hairs of one side. True lateral or dorsal positions are impossible, because of the lateral hairs and the dorsal arch of hairs. The semi-upright position is one that an intact animal, capable of righting itself, could transform into an upright position by the simple process of seizing the substrate with the legs. Thus, purely from a structural standpoint, these caterpillars are designed to land more often on the feet than otherwise.

Dropping preserved larvae (10 larvae, 5 trials each in each position) from a height of 30 cm. gave the following results: held upright when released, they landed in 60% of the falls on the feet and 40% in the semi-upright position; held head downward, head upward, or upside down, they landed 20% upright, 40% semi-upright, and 40% semi-supine. Dropping etherized larvae (5 larvae, 10 trials each in each position) gave comparable results. These show the structural weighting toward landing on the feet noted above. It is obvious that it is only necessary for the larvae to get into an upright or nearly upright position when releasing themselves for them to make landings on the feet that are perfect or so nearly so as to be indistinguishable from perfect.

EXPERIMENTS WITH MUTILATED LARVAE

It is obvious that the long hairs play an important part in the ability of this form to land on the feet, and experiments were accordingly undertaken involving the removal of various sets of these hairs. With all the long hairs pulled out, larvae (14 individuals) at 20 cm. and 30 cm. and presumably at all other heights also, landed on the feet perfectly, if they released themselves spontaneously from the glass rod or were dropped from the right side up position. If dropped from any other position, they landed imperfectly, usually falling straight downward and rolling to an upright stance. With the laterally extending hairs removed (8 individuals), either on both sides or one side, caterpillars could right themselves from the rod, but did not land perfectly if dropped head up or head down, as they did with the lateral hairs on. If dropped right side up, they still landed on the feet, but if dropped sidewise or upside down they showed imperfect landings. Obviously the hairs play a part in the ability to land on the feet, but not the only part.

Since the last contact with a support, before falling, in the normal larva is through the anal legs and usually also the third and fourth pairs

of prolegs, larvae (12 individuals) with these removed were tested for their ability to land on the feet. With the anal legs removed, the larvae still executed perfect landings, using the third and fourth pairs of abdominal legs, when releasing spontaneously. One of the larvae so operated upon made perfect landings from various heights using the second pair of prolegs. These larvae occasionally did not execute the usual reversal of direction when falling, apparently rolling over as they released themselves. When normal, these had turned end for end in righting, and this is an interesting case of adaptation to new conditions.

Caterpillars (5 individuals) with abdominal segments 5, 6, 7, 8, 9, and 10 cut off, after ligation between abdominal segments 4 and 5 to prevent loss of blood, when tested immediately after the operation showed an inability to land on the feet when releasing themselves spontaneously. They seemed to release too soon; that is, they extended the anterior parts of the bodies, releasing the first two pairs of prolegs, as they normally did, as if they "expected" to have the third and fourth pairs of prolegs and the anal legs still attached. Using the forceps, these caterpillars landed on the feet only from the right side up position or the head down position. After they were allowed to creep about for ten to twenty minutes, however, the ability to land on the feet when releasing spontaneously was regained. They held to the glass rod, in this case, with the second pair of prolegs, which were on their last segments (abdominal segment 4), and executed perfect landings, apparently having "learned", in the meantime, to get about under the new conditions. When dropped from the forceps, the same results were obtained as immediately after the operation. Thus, there was no improvement in the falling, but great improvement in releasing, clearly showing the essentially separate natures of these two stages.

Larvae (4 individuals) with the whole abdomen removed, after ligation on the first abdominal segment, were tested. The only functional parts of these fragments were the heads and thoracic segments. These pieces could not cling to the glass rod, and, therefore, tests of spontaneous dropping could not be made. If dropped from the forceps right side up, head up or head down, the fragments landed upright. If dropped upside down, they bounced into an upright position after landing. If these pieces were lifted quickly head downward and dropped without delay, they landed imperfectly and rolled to the upright position. If held for a few seconds in mid-air, however, they bent the heads dorsalward, in the anterior part of the characteristic sigmoid bending of the entire larva held head downward. This caused them to land in such a way that the forward projecting hairs on the first two thoracic segments forced them into the upright position.

Animals (3 individuals) with the heads and first two thoracic segments removed, after ligation, showed no spontaneous movements, even after long recovery periods—1 to 24 hours. They could be forced onto the glass rod by pushing it among their prolegs, but they did not drop spontaneously. Obviously, the anterior parts of the bodies were necessary for spontaneous movements. When dropped from the forceps, these fragments landed upright only if they left the forceps in the upright position. One caterpillar,

after having this operation performed, had the long hairs removed. It was, likewise, unable to land on the feet except when dropped in the upright position.

Caterpillars (6 individuals) which were decapitated, after ligation, also lost all spontaneous movements. They responded well to stimuli, such as pressure on the lateral abdominal walls which causes a bending of the body toward that side, but they did not crawl spontaneously, nor did they drop from the rod spontaneously. These fragments fell onto the feet when released right side up, but not when released otherwise. When landing other than correctly, however, they righted themselves normally, even from the upside down position. It is interesting to note that the fragments, including only the abdominal segments, showed characteristics like these decapitated fragments, except that they did not right themselves when landing other than on the feet. This suggests that the head, that is the supra-oesaphageal and sub-oesophageal ganglia, are not necessary for righting, but the thoracic ganglia, or some organ or organs in the thorax are,

Interpretations and Conclusions

These results show clearly that the phenomenon of landing on the feet in the caterpillars of *Euchaetias egle* occurs in three stages:

1. *The releasing stage.*—In this, the normal larva, using its posterior legs, swings over in a backward half-somersault to bring the body from an upside down position on the under-side of a leaf into an upright position as it releases its hold.

2. *The falling stage.*—This seems to be mostly mechanical; the upright position assumed during the first stage is maintained through the aerodynamic properties of the body of the animal.

3. *The landing stage.*—The animal, landing upright or a little off the upright position, seizes the substrate immediately to make either of these a landing on the feet.

In a sense, the release of a larva determines the whole course of the following events. It is during this that the larva gets itself into a position which will produce a correct landing without further effort or motion, except longitudinal contraction of the body. While the larva ordinarily uses the anal legs and the third and fourth pairs of prolegs for this feat, it can still manage to make the inversion even with these removed. It can even, under these conditions, show a new technique not exhibited by the normal larva, that of rolling over instead of turning end for end. This plasticity in an animal with a nervous system having a great degree of local control, is remarkable. Another evidence of a certain degree of adaptability in the larva is the ability to land on the feet when dropped from a head up or head down position, or when forced to drop from a support to which it has only the thoracic legs attached. The ability in these cases is important probably in bringing the animal onto the feet when striking objects during a fall and is brought about by the assumption of the special sigmoid shape of the body. The importance of this shape during falling is discussed below.

As soon as it releases itself, the caterpillar contracts longitudinally, and this produces a contour strongly favoring falling in the upright position. The cross-section of the body is streamlined dorso-ventrally, and the sides are armed with lateral projections which serve as primitive airfoils (fig. 4). If the animal tends to tilt toward either side, the surface area of the airfoil in the airstream on that side is increased, while the surface area on the other side is decreased. This results from the fact that the lateral tufts are above

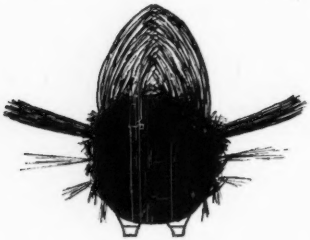
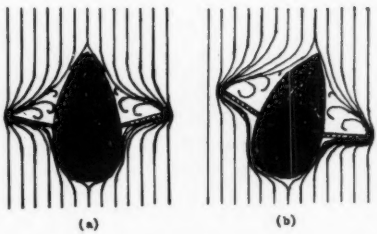


Fig. 4. Diagrammatic cross-section of the body of the caterpillar of *Euchaetias egle* showing the contours produced by the body-hairs. The tubercles from which the hairs arise are not on the same plane (cf. fig. 2), but for simplicity they are here pictured as if they were.

the mid-line of the body and curve upward, producing a slight dihedral. This tends to return the animal to the upright position (fig. 5). If the body tilts forward or backward, the increased air resistance on the projecting hairs on the lower part in either case forces that part upward until the animal is again level. This was shown experimentally with the fragments consisting of the head and thoracic segments only which were forced by the forward projecting hairs into an upright position. The general structure of the hairs comprising the tufts is such that the lateral "wings" do not decrease the rate of fall of the larva greatly, but they can produce enough force in the airstream to maintain an upright position.

Fig. 5. Hypothetical airstreams around the cross-sectional contours of the caterpillar of *Euchaetias egle:* (a) airstream around the upright body showing symmetrical distribution of air resistance, (b) airstream around the body when tilted slightly to one side showing increased air resistance on the lower side. The body-form is highly schematized, and the airflow through the lateral tufts is neglected.



The assumption of a sigmoid shape by the larva when head up or head down makes it possible, through forces on the anteriorly and posteriorly projecting hairs and on the lateral tufts, for the larva to resume the upright position. Animals with heads removed, do not assume this shape, and they accordingly fall incorrectly, while small fragments consisting only of the head and thorax do assume the anterior part of the sigmoid shape and

manage to fall on the feet. Animals with the long hairs removed, likewise fail to land on the feet from head down or head up starts. The ability to assume a special shape when in these positions indicates the possession of a statoreceptor by the larva, for it is not probable that the eyes in this form are sufficiently highly developed to be utilized by the animal to determine its orientation visually. Obviously, these experiments do not allow any conclusion as to the location or the properties of this statoreceptive organ.

To test the essentially physical interpretation of falling given above, artificial caterpillars were constructed from cylinders of balsa wood and strips of paper, producing the dorso-ventral streamlining and the lateral "wings." These, when dropped, showed the same properties as dead larvae, thus further confirming this interpretation.

The ability of caterpillars with lateral tufts removed, or with all the hairs removed, to execute perfect landings on the feet when dropping spontaneously shows the great importance of the releasing stage in this phenomenon. Apparently the center of gravity of the body of the animal is below the mid-line dorso-ventrally, and this tends to maintain the upright position when once attained. That this is not sufficient to bring about all the righting in mid-air is clearly shown by the fact that hairless larvae dropped head downward do not make perfect landings, while larvae with hairs do. The role of the dorsal arch of hairs in keeping the center of gravity below the mid-line is worth noting. This arch essentially produces a body about twice as high as it is wide, without raising the center of gravity appreciably, since the hairs are relatively light as compared, for instance, with the weight of tissue whch would be necessary were the whole body wall to be produced into this streamlining arch.

It is interesting to compare the ability of this species of caterpillar to land on the feet with the lack of this ability in the monarch butterfly caterpillar, *Danaus menippe*, which is found on the same host plant, and which, especially in the early instars, show the same tendency to drop when disturbed. The latter species assumes a death-feigning position as it drops and does not land on the feet at all. The possibility is that, lacking the body-hairs of *Euchaetias*, the monarch larvae cannot perform this feat and have become adapted to another form of escape. Another interesting comparison is between the reaction of these two species, which drop when disturbed, and that of caterpillars, such as those of *Samia cecropia*, which feed on leaves of trees and which cannot be dislodged, except by forcibly pulling them off, and often it is necessary to injure them before they release. The adjustment to the environment is obvious—it is a simple matter for a milkweed-caterpillar which has fallen from its host to regain its former position or to reach some other milkweed plant; it would not be so simple for a caterpillar feeding on the leaves of a tree to regain its previous position. However, preliminary observations I have made on larvae of a species of *Halisidota* (Family: Arctiidae) indicate that these too may be able to land on the feet when falling, and, since these feed on leaves of trees, they would have the same difficulty regaining a feeding position as the cecropia caterpillars. Perhaps the difference in behavior is also related to the difference in

activity between these smaller forms, which move energetically, and the larger caterpillars, which are quite sluggish.

Summary

Larvae of the milkweed-moth, *Euchaetias egle*, are able to land on the feet when falling. This seems to occur in three stages: (1) the releasing stage, in which larvae so release themselves, usually using the anal legs and the third and fourth pairs of prolegs, that they start their falls in an upright position; (2) the falling stage, in which the contour of the body, determined chiefly by the body-hairs, is the important factor; and (3) the landing stage, in which the caterpillars, whose structure is such that there are only a few possible landing positions, seize the substrate. The most important structural features of the bodies of the animals for preserving the upright position during falling are: (1) dorso-ventral streamlining produced by a dorsal arch of hairs on the abdominal segments, (2) lateral airfoils in the form of tufts of hairs extending laterally from the abdominal segments, and (3) a center of gravity below the mid-line, or at least below the level of attachment of the lateral tufts. These anatomical features not only maintain the animals in an upright position during falling, when once this position is attained, but they also enable the larvae to attain this position, if it is lost, by bending the bodies into certain appropriate forms. Normal larvae show a characteristic behavior pattern in releasing themselves from a support preparatory to falling, but they show some ability to modify this pattern, particularly when the appendages ordinarily used in releasing are removed.

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Studies on Monogenetic Trematodes

XII. Dactylogyridae from Wisconsin Fishes*

John D. Mizelle and Bro. Regis Regensberger, C.S.C.

The material treated herein was collected from Wisconsin waters during the summer of 1943 by Dr. R. V. Bangham of the Department of Zoology, Wooster College, Wooster, Ohio. All of the available parasites up to a maximum of 20 specimens were used in the treatment of each species. Only one, namely *Dactylogyrus eucalius* from the brook stickleback, is new. The host distribution of the remaining 18 species is as follows: *Actinocleidus fergusoni* from the bluegill sunfish *(Lepomis macrochirus)*, *A. fusiformis* from the large-mouth base (*Huro salmoides*), *A. unguis* from the large-mouth bass *(Huro salmoides)*, *Cleidodiscus aculeatus* from the wall-eyed pike *(Stizostedion vitreum)*, *C. alatus* from the rock bass *(Ambloplites rupestris)*, *C. capax* from the black crappie *(Pomoxis nigro-maculatus)*, *C. pricei* from the brown bullhead *(Ameiurus nebulosus)*, *C. robustus* from the bluegill sunfish *(Lepomis macrochirus)* and the pumpkinseed sunfish *(Lepomis gibbosus)*, *C. stentor* from the rock bass *(Ambloplites rupestris)*, *Urocleidus acer* from the bluegill sunfish *(Lepomis macrochirus)*, *U. adspectus* from the yellow perch *(Perca flavescens)*, *U. chautauquensis* from the rock bass *(Ambloplites rupestris)*, *U. dispar* from the bluegill sunfish *(Lepomis macrochirus)*, *U. ferox* from the bluegill sunfish *(Lepomis macrochirus)*, *U. furcatus* from the large-mouth bass *(Huro salmoides)*, *U. helicis* from the pumpkinseed sunfish *(Lepomis gibbosus)*, *U. principalis* from the large-mouth bass *(Huro salmoides)*, and *Tetraonchus monenteron* from the northern pike *(Esox lucius)*.

Methods involved herein with reference to the preparation of the specimens for microscopic study, are those given by Mizelle in 1938. Unless otherwise indicated the quotations used in the comparative and redescriptions are those given by the original authors. In some cases the species placed in given genera do not wholly agree with the generic diagnosis and clarification must await revision of the different subfamilies. The outline of the haptor in many instances is given as including a number of sides and it is understood that the junction of the haptor with the peduncle is considered as one of these sides. In case of previous records of parasites from Reelfoot Lake, the nearest town was cited as Ridgely, Tennessee. Dr. C. L. Baker, Director of the Reelfoot Lake Biological Station, had advised the authors that this is incorrect and that Tiptonville, Tennessee should have been cited in this regard. Therefore both towns have been cited in this paper with the former town (Ridgely) in parenthesis. In future publications Tiptonville will alone be cited and Ridgely will be deleted. It will be noted in some instances that the anchor wings are interpreted as pouch-like structures. Confirmation of this must await sectioned material.

* Contribution from the Department of Biology, University of Notre Dame, Notre Dame, Indiana.

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The authors wish to express their thanks and appreciation to Dr. R. V. Bangham, Head of the Department of Zoology, Wooster College, Wooster, Ohio, for the opportunity of studying the parasites involved in this investigation. They are also grateful to Mr. D. John O'Donnell, Area Biologist of the Conservation Department of the State of Wisconsin, for supplying additional host specimens of the brook stickleback, *Eucalia inconstans*.

ACTINOCLEIDUS FERGUSONI Mizelle, 1938

Pl. 1, Figs. 1-7

Host and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Bass Lake (Hatchery), Carrol Lake, Madeline Lake, Minocqua Thoroughfare along Woodruff Hatchery (all) near Woodruff, Wis., and Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis.

Previously Reported Hosts and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Lake Senachwine, Henry, Ill., Boomer Creek, Stillwater, Okla. (Mizelle 1938), Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), Reelfoot Lake, Tiptonville (Ridgely), Tenn., Lake Okeechobee, Moore Haven, Fla., Canal, North Everglades, Fla. (Mizelle and Brennan 1942). Orange-Spotted Sunfish *Lepomis humilis,* Local Ponds and Streams near Stillwater, Okla. (Seamster 1938).

Specimens Studied.—Twelve.

Comparative Description.—Body length 0.396 mm. (0.324-0.486 mm.) "0.379 mm. (0.330-0.444 mm.)," greatest body width 0.066 mm. (0.043-0.095 mm.) "0.056 mm. (0.045-0.083 mm.)." Transverse diameter of pharynx 0.024 mm. (0.018-0.027 mm.) "0.017 mm. (0.012-0.025 mm.)." Anterior anchor length 0.030 mm. (0.027-0.031 mm.) "0.025 mm. (0.023-0.027 mm.)," posterior anchor length 0.026 mm. (0.022-0.029 mm.) "0.023 mm. (0.021-0.025 mm.)." Anterior bar length 0.036 mm. (0.029-0.041 mm.) "0.029 mm. (0.025-033 mm.)," posterior bar length 0.023 mm. (0.020-0.025 mm.) "0.019 mm. (0.012-0.025 mm.)." Cirrus length 0.035 mm. (0.025-0.041 mm.) "0.023 mm. (0.021-0.028 mm)." Hook lengths 0.009-0.014 mm. "0.009-0.015 mm." The following measurements (in quotations) were not given in the original description but were supplemented by Mizelle and Brennan (1942). Haptor width 0.063 mm. (0.052-0.073 mm.) "0.043-0.064 mm.," haptor length 0.061 mm. (0.043-0.086 mm.) "0.030-0.051 mm." Anterior anchor base width (greatest) 0.010 mm. (0.008-0.012 mm.) "0.006-0.011 mm," posterior anchor base width (greatest) 0.009 mm. (0.008-0.011 mm.) "0.009 mm." The present measurement of the accessory piece is 0.022 mm. (0.018-0.023 mm.) and is supplementary. Some of the measurements recorded by Mizelle and Brennan (1942) in their comparative description do not agree with those of the original description and this paper (Mizelle and Brennan 1942) should be referred to for these. The cirrus in the present work was observed to possess a small projection at the base and the accessory piece presented a knob which showed a line of fusion with the main portion of this structure (Pl. 1, Figs. 1, 2)). The posterior eye spots are larger and closer together than those of the anterior pair and members of both pairs are composed of individual melanistic granules which separate readily on applica-

tion of pressure. The cephalic lobes are moderate in development and the pharynx is subcircular in outline (dorsal view). The haptoral bars differ somewhat from those in the original description (Pl. 1, Figs. 3, 4 and Mizelle 1938, Pl. 5, Figs. 149, 151). The vaginal tube (Pl. 1, Fig. 5) and the characteristic and uniform hooks (Pl. 1, Figs. 5, 7) together with the copulatory complex make this species unique. Mizelle and Brennan (1942) suggested it quite possible that this parasite might be a variation of *A. gracilis* Mueller, 1937, but since no specimens have been found to possess an undulate cirrus, which is characteristic of Mueller's species, *A. fergusoni* is considered to be valid.

ACTINOCLEIDUS FUSIFORMIS (Mueller, 1934) Mueller, 1937

Pl. 1, Figs. 8-11

Synonyms.—*Ancyrocephalus cruciatus* (Wedl, 1858) see Cooper 1915; *Cleidodiscus fusiformis* Mueller, 1934.

Host and Localities.—Large-Mouth Bass *Huro salmoides,* Pinkeye Lake near Land O'Lakes, Wis. and Chetac Lake near Birchwood, Wis.

Previously Reported Hosts and Localities.— Small-Mouth Bass *Micropterus dolomieu,* State Fish Hatchery Reservoir, Constantia, N. Y. (Mueller 1934), Ohio Hatcheries, London, Ohio, Syracuse, N. Y. (Mueller 1936), Cove Creek, Caryville, Tenn. (Mizelle 1940). Kentucky or spotted Bass *Micropterus punctulatus,* Norris Lake, Norris, Tenn., Cold Creek below Norris Dam (Tenn.), Cove Creek, Caryville, Tenn. (Mizelle 1940). Large-Mouth Bass *Huro salmoides,* Peace River, Fla. (Mueller 1937), Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), New Roads, La. (Summers and Bennett 1938), Hatchery, Norris, Tenn. (Mizelle 1940), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943).

Specimens Studied.—Three.

The characters presented by the three specimens of this species available in the present work, differ very little from those recorded in the redescription (Mizelle 1940). The hooks have bases (Pl. 1, Figs. 10, 11) which are a bit more ovate than originally figured (Mueller 1936, Pl. 12, Fig. 8) and those of pair number five (seven of Mueller) in addition to being a bit shorter than the rest of the hooks, have bases that are smaller but no less ovate. All of the present measurements except one for the posterior bar (0.032 mm.) lie within those in the redescription. The measurement (posterior bar) in this instance is only three microns less than that referred to. The highly characteristic copulatory complex (Pl. 1, Figs. 8, 9 and Mizelle 1940, Figs. 5, 6) together with the articulated bars and the hollow posterior anchors (Mizelle 1940, Figs. 1-4) make the identity of this species unmistakable.

ACTINOCLEIDUS UNGUIS Mizelle and Cronin, 1943

Pl. 1, Figs. 12, 13

Host and Locality.—Large-Mouth Bass *Huro salmoides,* Pinkeye Lake near Land O'Lakes, Wis.

Previously Reported Host and Locality.—Large-Mouth Bass *Huro sal-*

moides, Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943).

Specimens Studied.—Three.

The principal differences between the Wisconsin and Tennessee specimens are for the most part quantitative and the reader is referred to the original description for morphological details not given herein. Body length 0.972 mm. (0.666-1.170 mm.) "0.999-1.256 mm," greatest body width 0.237 mm. (0.185-0.288 mm.) "0.221-0.321 mm." Pharynx somewhat larger than originally described, 0.071 mm. (0.059-0.086 mm.), in transverse diameter as opposed to 0.037-0.050 mm. The haptor is not characteristically developed in this member of the genus and the bars and anchors are very small for the size of the attachment organ. Haptor width 0.185 mm. (0.159-0.215 mm.) "0.221-0.357 mm," haptor length 0.108 mm. (0.099-0.116 mm.) "0.142 mm." The presence of bars composed of individual halves which articulate with each other (Mizelle and Cronin 1943, Pl. 1, Figs. 55, 56) make this species rather singular. Anterior bar length 0.029 mm. "0.032 mm," posterior bar length 0.017 mm. (0.016-0.018 mm.) "0.018 mm." Anchors somewhat heavier than originally figured (Pl. 1, Figs. 12, 13 and Mizelle and Cronin 1943, Pl. 1, Figs. 57, 58); length of anterior anchors 0.024 mm. (0.023-0.025 mm.) "0.026-0.032 mm.," greatest width of base 0.012 mm. (0.011-0.013 mm.) "0.009-0.011 mm;" posterior anchor length 0.022 mm. (0.021-0.023 mm.) "0.032 mm.," greatest width of base 0.011 mm. (0.010-0.013 mm.) "0.011-0.012 mm." Hooks characteristically arranged in the present specimens (Mizelle 1938) with members of pair number five situated between the anterior and posterior bars and anchors instead of "between the arms of the posterior bar" (Mizelle and Cronin 1943). Hook lengths 0.014-0.018 mm. "0.014-0.020 mm." Copulatory complex unmistakably that of *A. unguis* (Mizelle and Cronin 1943, Figs. 61, 62). In the present specimens the testis is noticeably larger than the ovary and is situated with the anterior border in contact (dorsal view) with the posterior margin of the ovary. The testis was not observed in the material used in the original description.

Cleidodiscus aculeatus (Van Cleave and Mueller, 1932) new comb.

Pl. 1, Figs. 14-25

Synonyms.—Ancyrocephalus aculeatus Van Cleave and Mueller, 1932; *Urocleidus aculeatus* (Van Cleave and Mueller, 1932) Mueller, 1934.

Host and Localities.—Wall-Eyed Pike *Stizostedion vitreum,* Clear Lake, Big Arbor Vitae Lake, Johnson Lake, (all) near Woodruff, Wis. and Squaw Lake near Lac Du Flambeau, Wis.

Previously Reported Host and Locality.—Wall-Eyed Pike *Stizostedion vitreum,* Oneida Lake, N. Y. (Van Cleave and Mueller 1932, and Mueller 1934, 1936).

Specimens Studied.—Twenty.

Redescription.—Moderately large dactylogyrid species, length 0.716 mm. (0.468-0.954 mm.) "about 0.85 mm. long though some worms as short as 0.65 mm. and others as long as 0.95 mm. have been observed." Greatest body

width 0.156 mm. (0.129-0.189 mm.) "Average specimens 0.17 mm. in diameter." Cephalic lobes usually well developed; eye spots four in number, members of the posterior pair larger and closer together than those of the anterior pair. Pharynx subspherical to broadly ovate (longitudinally elongate) and 0.049 mm. (0.032-0.59 mm.) in transverse diameter. Peduncle usually short and wide; haptor irregularly hexagonal in outline, haptor width 0.133 mm. (0.111-0.163 mm.), length 0.102 mm. (0.081-0.129 mm.) "diameter ranging from 0.082 to 0.137 mm. and in length from 0.088 to 0.120 mm." Haptoral bars well developed, ventral shorter than dorsal and possessing a cavity which is more highly developed than that in the dorsal bar (Pl. 1, Figs. 20, 21 and Van Cleave and Mueller 1932, Pl. 4, Figs. 2, 4). Length of ventral bar 0.041 mm. (0.036-0.045 mm.), length of dorsal bar 0.046 mm. (0.041-0.047 mm.) "each about 0.03 mm. in transverse dimensions" (Mueller 1936). Anchors similar in shape, different in size, and with solid shafts and points though a narrow groove can be seen in the shafts when viewed from the concave side; anchor wings well developed (Pl. 1, Figs. 14-16). Superficial root of ventral anchor base much longer, and deep root frequentely shorter, than corresponding structures on the dorsal anchors. Ventral anchor length 0.091 mm. (0.081-0.104 mm.), greatest width of base 0.043 mm. (0.040-0.047 mm.). Dorsal anchor length 0.072 mm. (0.057-0.079 mm.), greatest width of base 0.039 mm. (0.031-0.043 mm.) "longest arc obtainable from the anterior extremity of the large hooks to the curved portion of the hook ranged from 0.082 to 0.110 mm." "Over-all length of anchors, not following the curve, 0.07 mm. for the dorsal, 0.09 mm. for the ventral, at times slightly more" (Mueller 1936). Hooks fourteen in number, subequal in length in a given specimen, and normal in arrangement (Mizelle 1938) with members of pair number five situated between the ventral anchor shafts. Each hook is composed of 1) an ovate base shorter than the 2) elongate shaft, 3) a sickle-shaped termination, and 4) an opposable piece which is decurved toward the base (Pl. 1, Figs. 17-19. The posterior projection which arises from the convex surface of the sickle-shaped termination is large and at times appears hollow. Hook lengths 0.014-0.022 mm. "about 0.017 mm. long." The hooks figured in the original description (Van Cleave and Mueller 1932, Pl. 4, Figs. 2, 3) differ from those observed in this work by 1) the absence of a posteriorly projecting structure arising from the convex surface of the sickle-shaped termination, 2) absence of an opposable piece, 3) possession of more broadly ovate bases, and 4) location of one hook of pair number five near the ventral surface and the other near the dorsal surface of the haptor. Gonads tandem in arrangement, ovary subcircular in outline (dorsal view), containing many large nucleated eggs, and situated in front of the broadly ovate (longitudinally elongate) and larger testis. Vagina, seminal receptacle, seminal vesicle, prostates, and intestinal crura not observed. Copulatory complex well developed and comprised of an elongate cirrus and an accessory piece which are articulated with each other basally (Pl. 1, Figs. 22-25). The accessory piece is often disarticulated from the cirrus as shown in Pl. 1, Fig. 22. Cirrus length 0.046 mm. (0.037-0.056 mm.), accessory piece length 0.028 mm. (0.022-0.031 mm.) "Cirrus—about 0.025-0.030 mm. in length" (Mueller 1936). The copulatory complex figured for this species by Van Cleave and

Mueller in 1932 (Pl. 4, Fig. 1) and Mueller in 1936 (Pl. 14, Fig. 17) does not remotely resemble that as observed by the present authors. The vitellaria generally are so heavily developed that the copulatory complex is obscured, and this probably accounts for the erroneous representations referred to above. Since all of the 63 parasites recovered from 8 host specimens in the present work were all the same species and possessed haptoral armament unmistakably that as described for *Cleidodiscus aculeatus* by the original authors, it is concluded that the original and subsequent observations (Mueller 1936) unfortunately were based on poor material in regard to the copulatory complex. It should also be noted here that only one species of Tetraonchinae has been recorded for the wall-eyed pike (*Stizostedion vitreum*).It is interesting to observe that the copulatory complex of *C. aculeatus* closely resembles that of *Urocleidus adspectus* though the haptoral armament is very different for the two species. Speculations here with reference to convergent evolution, or possibly speciation, or perhaps environmental influence (host) are interesting. Transfer of this species to the genus *Cleidodiscus* is being made on the basis of the articulation between the cirrus and the accessory piece.

CLEIDODISCUS ALATUS Mueller, 1938

Pl. 1, Figs. 26-40

Host and Localities.—Rock Bass *Ambloplites rupestris,* Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis. and Blue Lake near Minocqua, Wis.

Previously Reported Host and Locality.—Rock Bass *Ambloplites rupestris,* Chautaqua Lake, N. Y. (Mueller 1938).

Specimens Studied.—Two.

Redescription.—Length 0.414-0.540 mm. "0.44 mm.," greatest body width 0.082-0.090 mm. "0.088 mm.," cuticle thin and smooth. Cephalic lobes moderately developed. Eye spots four, members of the posterior pair larger and closer together "farther apart' than those of the anterior pair. Pharynx broadly ovate, vertically elongate in diagonal view and 0.018-0.021 mm. by 0.025-0.031 mm. Peduncle moderate to elongate, haptor roughly pentagonal in outline and 0.051-0.073 mm. long by 0.052-0.077 mm. wide. Haptoral bars dissimilar in size and shape, ventral conspicuously larger (Pl. 1, Figs. 33, 34 and Mueller 1938, Pl. 2, Figs. 20, 21). Ventral bar length 0.036 mm. "0.040 mm.," dorsal bar length 0.023-0.027 mm. "0.030 mm." Anchors with bifurcate bases which possess small deep roots and large superficial roots; shafts hollow. Dorsal anchor points solid and unite with the anchor shafts to form only a suggestion of an angle (Pl. 1, Figs. 30, 31). Ventral anchor shaft more abruptly bent than shown in the original description; points hollow (Pl. 1, Fig. 32 and Mueller 1938, Pl. 2, Fig. 24). Anchor wings well developed and much higher on the ventral than on the dorsal anchor shafts. The development of these structures in this species indicates that they may not be chitinous threads but rather, baglike structures which partially enclose the anchors. Cavities in ventral anchor shafts more highly developed than in the dorsal anchor shafts and in each case arise proximally, nearer the convex shaft surface as in the case of *Urocleidus adspectus* Mueller, 1936,

(Mizelle and Donahue 1944, Pl. 2, Figs. 54, 59, 60). Ventral anchor length 0.035-0.036 mm. "0.040 mm.," greatest width of ventral anchor base 0.018-0.023 mm.; dorsal anchor length 0.027-0.030 mm. "0.030 mm.," greatest width of base 0.013 mm. Hooks of subequal length in a given specimen (except those of Nos. 1 and 5) fourteen in number, normal in arrangement (Mizelle 1938), and each with a conspicuous opposable piece. Hooks of pair number five situated between the ventral anchor shafts. Hooks of pairs numbers one and five with small spherical-to-ovate bases conspicuously shorter than their respective shafts (Pl. 1, Figs. 37, 38). Remaining hooks with relatively large ovate bases which are shorter than the slender shafts. Hook lengths 0.012-0.020 mm. "0.020 mm." Hooks of pairs numbers one and five smallest. Cirrus and accessory piece non-articulate with each other (Pl. 1, Figs. 26-29 and Mueller 1938, Pl. 2, Fig. 17). Cirrus length 0.043-0.047 mm.; accessory piece length 0.045-0.047 mm. Gonads ovate in outline and tandem in arrangement; ovary larger than, and situated anterior to, the testis. Ovary filled with conspicuously nucleated eggs which become larger in a posterio-anterior direction. Vagina located near the body midlength to the left of the median axis and opening dorsally. Vaginal canal highly chitinized and expanded to produce a thick-walled but relatively small seminal receptacle (Pl. 1, Figs. 39, 40, and Mueller 1938, Pl. 2, Figs. 18, 19). Seminal vesicle and prostates not observed. Vitellaria moderately developed and extend from the posterior border of the pharynx to the peduncle.

The lack of an articulation between the base of the cirrus and the accessory piece together with the dorsally opening vagina in this species make its generic position somewhat uncertain. It is being retained in the genus *Cleidodiscus* pending a future revision of the subfamily.

CLEIDODISCUS CAPAX Mizelle, 1936

Pl. 1, Figs. 41-50

Host and Localities.—Black Crappie *Pomoxis nigro-maculatus*, Big Arbor Vitae Lake near Woodruff, Wis., Chetac Lake near Birchwood, Wis., and Lake-du-Bay (Knowlton Flowage) near Mosinee, Wis.

Previously Reported Hosts and Localities.—White Crappie *Pomoxis annularis*, Lake Decatur, Decatur, Ill., Illinois River, Havana, Ill. (Mizelle 1936), Reelfoot Lake, Tiptonville (Ridgely), Tenn., Illinois River, Chillicothe, Ill. (Mizelle, La Grave, and O'Shaughnessy 1943). Black Crappie *Pomoxis nigro-maculatus*, Lake Senachwine, Henry, Ill., Illinois River, Havana, Ill. (Mizelle 1936), Lakeland, Md., Oneida Lake, N. Y. (Mueller 1937), Reelfoot Lake, Tiptonville (Ridgely), Tenn., Illinois River, Chillicothe, Ill. (Mizelle, La Grave, and O'Shaughnessy 1943).

Specimens Studied.—Eighteen.

Specimens of this species from the above localities (Wisconsin) agree very well with the original description except for 1) some irregularities in the morphology of the bars and anchors (Pl. 1, Figs. 43-47 and Mizelle 1938, Pl. 4, Figs. 69, 70, 74, 75), 2) the fact that the accessory piece apparently extends more basally in some of the present specimens than originally figured (Pl. 1, Fig. 41, and Mizelle 1938, Pl. 4, Fig. 67), and 3) the presence of

bits of melanistic pigment irregularly distributed in some of the specimens. Some discrepancies in the size of the specimens and structural parts are evident from the following comparative measurements.

Body length 1.308 mm. (1.080-1.800 mm.), "1.603 mm. (0.959-2.050 mm.,)" greatest body width 0.211 mm. (0.144-0.288 mm.) "0.301 mm. (0.180-0.410 mm." Pharynx ovate to subcircular in outline (dorsal view) and enlarged at times to the extent of increasing the body width in this region. Transverse diameter of pharynx 0.126 mm. (0.090-0.172 mm.) "0.139 mm. (0.082-0.164 mm.)" Haptoral width 0.126 mm. (0.099-0.168 mm.) "0.158 mm. (0.115-0.180 mm.,)" haptoral length 0.089 mm. (0.073-0.108 mm.) "0.106 mm. (0.090-0.123 mm.)" Ventral bar length 0.032 mm. (0.027-0.036 mm.) "0.032 mm. (0.028-0.034 mm.,)" dorsal bar length 0.030 mm. (0.027-0.036 mm.) "0.030 mm. (0.024-0.036 mm.)." Ventral anchor length 0.033 mm. (0.027-0.036 mm.) "0.032 mm. (0.026-0.038 mm.)," greatest width of ventral anchor base 0.029 mm. (0.018-0.034 mm.) "0.027 mm. (0.019-0.036 mm.)." Dorsal anchor length 0.030 mm. (0.024-0.034 mm.) "0.031 mm. (0.026-0.038 mm.)," greatest width of dorsal anchor base 0.021 mm. (0.018-0.027 mm.) "0.023 mm. (0.019-0.029 mm.)." Hook lengths 0.014-0.020 mm. "0.013-0.019 mm." (Pl. 1, Figs. 48-50). The cirrus length and accessory piece length in the present specimens are 0.090 mm. (0.081-0.099 mm.) and 0.071 mm. (0.059-0.081 mm.) respectively. These two sets of measurements and the figures for the hooks are supplementary since they have not been presented previously for this species. This is one of the larger species of Tetraonchinae and has been recorded only from the white and black crappies.

CLEIDODISCUS PRICEI Mueller, 1936

Pl. 1, Figs. 51-55

Host and Locality.—Brown Bullhead *Ameiurus nebulosus,* Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis.

Previously Reported Hosts and Localities.—Channel Catfish *Ictalurus lacustris punctatus,* Myakka River, Fla., Lake Okeechobee, Fla. (Mueller 1936a), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943). Yellow Bullhead *Ameiurus natalis,* Myakka River, Fla., Lake Okeechobee, Fla. (Mueller 1936a), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943). Brown Bullhead *Ameiurus nebulosus,* Myakka River, Fla., Lake Okeechobee, Fla. (Mueller 1936a), Oneida Lake, N. Y. (Mueller 1937), Dixon, Proulx, and Smoke Lakes (all) in Algonquin Park, Ontario, Canada (Mizelle and Donahue 1944). Black Bullhead *Ameiurus melas,* Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), Baton Rouge, La. (Summers and Bennett 1938), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943), Opeongo Lake, Algonquin Park, Ontario, Canada (Mizelle and Donahue 1944). Fulton Cat *Ictalurus furcatus,* Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943).

Specimens Studied.—Ten.

This very variable species, originally described by Mueller (1936a) was

commented on with reference to variation of the anchors by Seamster (1938) and comparatively described by Mizelle and Cronin (1943) on the basis of thirty-eight specimens. Since only a few measurements were given in the original description and also because the number of specimens used therein was not known, it is thought that a more complete picture can be gotten from the comparative rather than the original description. Aside from the variable shape (Pl. 1, Figs. 51, 52) of the dorsal bar, no new or striking variations (qualitative) were observed in the present specimens. Some quantitative differences however, are evident from the following measurements which consist of data from the present work and the comparative description. Length 0.545 mm. (0.378-0.720 mm.) "0.520 mm. (0.386-0.928 mm.," greatest body width 0.099 mm. (0.073-0.138 mm.) "0.080 mm. (0.057-0.114 mm.)" Transverse diameter of pharynx 0.038 mm. (0.029-0.045 mm.) "0.030 mm. (0.024-0.041 mm.)." Greatest width of haptor 0.095 mm. (0.077-0.120 mm.) "0.069 mm (0.043-0.100 mm.)," haptor length 0.075 mm. (0.065-0.086 mm.) "0.076 mm. (0.050-0.107 mm.)." Ventral bar length 0.043 mm. (0.040-0.047 mm.) "0.042 mm. (0.028-0.047 mm);" dorsal bar length 0.045 mm. (0.041-0.049 mm.) "0.045 mm. (0.029-0.052 mm.)." Ventral anchor length 0.051 mm. (0.047-0.054 mm.) "0.044 mm. (0.034-0.054 mm.)," greatest width of base 0.023 mm. (0.020-0.025 mm.) "0.011 mm. (0.008-0.016 mm.)." Dorsal anchor length 0.053 mm. (0.045-0.070 mm.) "0.048 mm. (0.035-0.074 mm.)," greatest width of base 0.023 mm. (0.014-0.031 mm.) "0.012 mm. (0.008-0.017 mm.)." Cirrus length 0.035 mm. (0.029-0.038 mm.) "0.034 mm. (0.025-0.054 mm.)." Accessory piece length 0.024 mm. (0.020-0.036 mm.) "0.032 mm. (0.022-0.055 mm.)." Hook lengths 0.013-0.018 mm. "0.013-0.018 mm." Each of the hooks is differentiated into an elongate-ovate base, a slender shaft, a sickle-shaped termination, an opposable piece, and a posteriorly projecting structure arising from the convex surface of the sickled-shaped termination. Hooks of pair number five are shorter than the rest of these structures in a given specimen (Pl. 1, Figs. 53-55).

CLEIDODISCUS ROBUSTUS Mueller, 1934

Synonyms.—*Cleidodiscus incisor* Mizelle, 1936; *Actinocleidus incisor* (Mizelle, 1934) Mueller, 1937; *A. incisor* (Mizelle, 1936) Summers and Bennett, 1938.

Hosts and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Chetac Lake near Birchwood, Wis., Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis., and Carrol Lake, and Minocqua Thoroughfare along Woodruff Hatchery (both) near Woodruff, Wis. Pumpkinseed Sunfish *Lepomis gibbosus,* Island Lake near Spooner, Wis.

Previously Reported Hosts and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Hatchery Ponds at London, Ohio (Mueller 1936), Illinois River, Havana, Ill., Chautauqua Lake, Havana, Ill., Horseshoe Lake, Cairo, Ill., Lake Decatur, Decatur, Ill., Lake Senachwine, Henry, Ill. (Mizelle 1936), Baton Rouge and New Roads, La. (Summers and Bennett 1938), Reelfoot Lake, Tiptonville (Ridgely), Tenn., Lake Okeechobee, Moore Haven, Fla. (Mizelle and Brennan 1942). Pumpkinseed Sunfish *Lepomis gibbosus,*

State Fish Hatchery Reservoir, Constantia, N. Y. (Mueller 1934), Syracuse, N. Y. (Mueller 1936). "Sunfish" and "Bass," Hatching Ponds near Syracuse, N. Y. (Mueller 1936). Green Sunfish *Lepomis cyanellus,* Hatchery Ponds, London, Ohio (Mueller 1936), Embarrass River, Urbana, Ill. (Mizelle 1938), Urbana, Ill. (Kimpel 1939).

Specimens Studied.—Fourteen.

After the original description of *Cleidodiscus robustus* in 1934, this species was described as *C. incisor* from Illinois (Mizelle 1936). In the latter description twenty specimens were used in the determination of measurements given. It is not known how many specimens were used in the original description. In 1942 Mizelle and Brennan did a comparative description between forms taken from Tennessee (3) and Florida (1) and those used in the description of *C. incisor* from Illinois. Some differences were cited but as these authors stated, the specimens from the southern localities were only four in number and the measurements obtained therefrom were considered insufficient for valid comparison with those obtained from the twenty specimens from Illinois. Fourteen specimens were used in the present work and it is thought that comparative measurements between these and those from the Illinois specimens (20) may be of some value. *C. robustus* is one of the larger species of North American freshwater Tetraonchinae being 1.486 mm. (0.990-2.070 mm.) "1.414 mm. (0.615-2.296 mm.)" long and 0.217 mm. (0.159-0.365 mm.) "0.216 mm. (0. 121-0.410 mm)" in greatest body width. Transverse diameter of pharynx 0.068 mm. (0.054-0.120 mm.) "0.076 mm. (0.046-0.123 mm.)"; haptor length 0.082 mm. (0.065-0.108 mm.) "0.106 mm. (0.082-0.139 mm)," haptor width 0.108 mm. (0.099-0.129 mm.) "0.111 mm. (0.092-0.148 mm.)." Ventral bar length 0.026 mm. (0.023-0.029 mm.) "0.028 mm. (0.025-0.032 mm.)," dorsal bar length 0.026 mm. (0.025-027 mm.) "0.027 mm. (0.024-0.029 mm.)." Ventral anchor length 0.027 mm. (0.025-0.032 mm.) "0.026 mm. (0.021-0.030 mm.)," greatest width of base 0.016 mm. (0.014-0.018 mm.) "0.012 mm. (0.010-0.017 mm.)," dorsal anchor length 0.024 mm. (0.023-0.025 mm.) "0.024 mm. (0.019-0.027 mm.)," greatest width of base 0.017 mm. (0.016-0.018 mm.) "0.012 mm. (0.009-0.017 mm.)." Haptoral hooks typical and varying from 0.014-0.021 mm. "0.013-0 023 mm." in length. The cirrus and accessory piece were not measured in the description of *C. incisor* and the following comparative measurements (in quotations) are from the paper by Mizelle and Brennan (1942). Cirrus length 0.084 mm. (0.072-0.094 mm.) "0.064-0.086 mm.," accessory piece length 0.054 mm. "0.051-0.056 mm.". Several of the present specimens contained bits of black pigment scattered throughout the body proper.

CLEIDODISCUS STENTOR Mueller, 1937

Pl. 2, Figs. 15-31

Host and Localities.—Rock Bass *Ambloplites rupestris,* Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis., and Blue Lake, near Minocqua, Wis.

Previously Reported Host and Locality.—Rock Bass, *Ambloplites rupestris,* Constantia, N.Y. (Mueller 1937).

Specimens Studied.—Twenty.

Redescription.—Length 0.468 mm. (0.360-0.576 mm.) "about 0.6 mm. long," greatest body width 0.085 mm. (0.064-0.116 mm.) and may occur at either end or in the middle; specimens frequently possess a construction near the midportion; cuticle smooth and thin. Cephalic lobes small to well developed; eye spots four in number, members of the posterior pair much larger and closer together than those of the anterior pair "anterior eyes smaller than the posterior, both equally spaced." The posterior eye spots are elongated diagonally or transversely to the body axis and infrequently contiguous or confluent with each other. Pharynx ovate to subspherical in outline (dorsal view) and 0.027 mm. (0.020-0.033 mm.) in transverse diameter "0.035 mm. in diameter." Peduncle moderate to extremely elongate; haptor hexagonal to ovate in outline (dorsal view) "wedge shaped," haptor width 0.080 mm. (0.056-0.095 mm.), length 0.078 mm. (0.060-0.116 mm.). Haptoral bars similar in size, dissimilar in shape. Ventral bar variable in shape, typically with ornate tripartite ends and a conspicuous projection on the posterior border (Pl. 2, Figs. 24-26, and Mueller 1937, Fig. K45) length 0.030 mm. (0.027-0.034 mm.). Dorsal bar variable in shape, with simple rounded or ornate ends, gently bent posteriorly in the midportion, usually with an uneven or elevated anterior border, and noticeably different from that figured in the original description in that a median spine or plate (best seen in side view) is present on the posterior border (Pl. 2, Figs. 21-23, Mueller 1937, Fig. K46. Dorsal bar length 0.030 mm. (0.025-0.036 mm.) "Bars—about 0.035 mm. long." Anchors similar in shape, subequal in size, and with hollow shafts and points (usually) which unite somewhat acutely (Pl. 2, Figs. 17-20 and Mueller 1937, Fig. K45). Anchor shafts relatively thick so that the internal cavities (not described nor figured in the original description) are often seen with difficulty. Cavity in dorsal anchors infrequently observed to be shortened and not to extend into the anchor points. Ventral anchor shafts conspicuously bent in the direction of the anchor points. Anchor wings well developed and usually larger though not necessarily higher, on the ventral anchor shafts. In addition to the hollow shafts and points, the anchors differ from those figured in the original description by the possession of bases which are conspicuously bifurcate. Ventral anchor length 0.044 mm. (0.036-0.049 mm.), greatest width of base 0.020 mm. (0.014-0.025 mm.); dorsal anchor length 0.040 mm. (0.036-0.043 mm.), greatest width of base 0.017 mm. (0.013-0.020 mm.) "Anchors equal, 0.05 mm. in greatest dimension." Hooks normal in arrangement (Mizelle 1938) and subequal in size (except members of pair number five) in a given specimen. Each hook composed of 1) an elongate-ovate base (except those of pair number five) approximately as long as the 2) slender solid shaft, 3) a sickle-shaped termination, and 4) an opposable piece (Pl. 2, Figs. 30, 31). Members of hook pair number five located between the ventral anchor shafts, morphologically similar to the other hooks, with bases conspicuously shorter than their respective shafts, and not as represented in the original description (Pl. 2, Fig. 30, and Mueller 1937, Fig. K45) in that the bases are more broadly ovate and an opposable piece is present. Length of hooks

other than those of pair number five, 0.015-0.023 mm. Length of hooks of pair number five 0.013-0.016 mm. "Hooks of pairs 1-6 equal, 0.019 mm. long." Hooks of pair number 7 (No. 5 of Mizelle 1938) were stated to be smaller. Copulatory complex composed of a basally articulate cirrus and accessory piece. Cirrus tubular with a moderate-sized base and inflated termination, accessory piece solid and somewhat shorter that the cirrus (Pl. 2, Figs. 15, 16 and Mueller 1937, Figs. K3, K4). Length of cirrus (measured across an arc) 0.050 mm. (0.045-0.058 mm.) "about 0.08 mm. long," accessory piece length 0.041 mm. (0.034-0.049 mm.) "about 0.05 mm. long." Only one large botuliform prostate, filled with a coarsely granular substance, observed. Seminal vesicle elongate and situated near the prostate. Vagina sinistral, situated near the body midlength, and opening laterally on the body margin. The vagina often contains a relatively large chitinous body which has a closed end directed laterally and an irregularly concave end directed mesially. This structure was described by Mueller as a seminal receptacle but is interpreted here to be a structure secreted by the vaginal wall. It has been observed to be absent frequently and does not lie at the end of the vaginal canal but enclosed within the vagina and frequently protrudes beyond the body surface (Pl. 2, Fig. 27). Gonads ovate in outline (dorsal view), ovary somewhat smaller than, and usually overlapped slightly by the testis which is situated posterior to the ovary. Vitellaria well developed and extend from the posterior border of the pharynx to the peduncle.

UROCLEIDUS ACER (Mueller, 1936) Mizelle and Hughes, 1938

Pl. 1, Figs. 68-72

Synonyms.—*Oncholocleidus acer* Mueller, 1936; *Pterocleidus acer* (Mueller, 1936) Mueller, 1937.

Host and Locality.—Bluegill Sunfish *Lepomis marcochirus,* Madeline Lake near Woodruff, Wis.

Previously Reported Hosts and Localities.—Pumpkinseed Sunfish *Lepomis gibbosus,* Cross Lake, N. Y. (Mueller, 1936). Bluegill Sunfish *Lepomis macrochirus,* Various Localities in Illinois (Mizelle 1938), Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Brennan 1942. Orange-Spotted Sunfish *Lepomis humilis,* Lake Senachwine, Henry, Ill. (Mizelle 1936).

Specimens Studied.—Two.

The two specimens available here were not particularly favorable for minute study and the haptor was missing from one of them. The copulatory complex (Pl. 1, Figs. 68, 69) is not as characteristic as that figured in the original description (Mueller 1936, Pl. 14, Fig. 35), but its identity is unmistakable and serves as a good character for this species. The following measurements are given for comparative purposes. Body length 0.324-0.504 mm. "0.35 mm.," greatest body width 0.082-0.103 mm.; transverse diameter of pharynx 0.022 mm. "0.02 mm.". Haptor well differentiated and 0.073 mm. "0.06 mm." in length; ventral anchor length 0.031 mm., greatest width of base 0.021 mm.; dorsal anchor length 0.031 mm., greatest width of base 0.017 mm. "Anchors 0.045-0.05 mm. in greatest straight dimension——."

Cirrus length 0.045-0.059 mm. "0.05 mm.". Haptoral hooks composed of a base, a shaft, a sickle-shaped termination, and an opposable piece (Pl. 1, Figs. 70-72). The bases of hooks of pair number five (seven of Mueller) are ovate and shorter than their respective shafts. The bases of the rest of the hooks are elliptical in outline and about as long as their respective shafts. Length of hooks of pair number five about 0.010 mm., length of remaining hooks approximately the same (0.018-0.020 mm.). These hooks were portrayed erroneously as pencil-like structures drawn out to a fine point, in the original description (Mueller 1936, Pl. 13, Fig. 9). Gonads situated in the anterior part of the posterior body half, considerably overlapping each other, and with the testis more anterior. Seminal vesicle, seminal receptacle, and vagina not observed with certainty. Vitellaria well developed and extend from the level of the anterior eye spots into the proximal portion of the peduncle.

UROCLEIDUS ADSPECTUS Mueller, 1936

Pl. 1, Figs. 73-77

Synonym.—*Cleidodiscus* sp. Mizelle and Donahue, 1944.

Host and Localities.—Yellow Perch *Perca flavescens*, Madeline Lake near Woodruff, Wis., and Pinkeye Lake near Land O'Lakes, Wis.

Previously Reported Host and Localities.—Yellow Perch *Perca flavescens*, Cross Lake, N. Y. (Mueller 1936), Long, Opeongo, and Proulx Lakes (all) in Algonquin Park, Ontario, Can. (Mizelle and Donahue 1944).

Specimens Studied.—Twenty.

The identity of this species has been in confusion since its original description by Mueller in 1936. Mizelle and Donahue (1944) identified it largely on the basis of the resemblance of the haptoral armament to that in the original description (Mueller 1936, Pl. 15, Figs. 49, 54, 55) and by the fact that apparently only one gill parasite occurs on gills of the yellow perch. They redescribed this parasite on the basis of sixteen specimens and it is thought that their redescription presents a rather accurate picture of the species since their findings have been confirmed in the present and other observations (unpublished). The copulatory complex presented by specimens used in the redescription, (Pl. 2, Figs. 64, 65) did not remotely resemble that figured in the original description (Mueller 1936, Pl. 14, Figs. 28, 29) and it was concluded that the structure as observed in their material represented a radical variation, a different species (doubtful), or that the original description was in error in this regard. Specimens used 1) in the redescription, 2) those on which *Cleidodiscus* sp. (Mizelle and Donohue 1944) from the yellow perch, was based, together with 3) the present (Pl. 1, Figs. 73, 74) and 4) others kindly furnished by Mueller from Dorothy Dunne Lake (New York), definitely show that the original description was in error in regard to the nature of the copulatory complex. Whether or not the accessory piece and cirrus are articulated proximally could not be definitely established from the material at hand and must await examination of live or possibly fresh material. In some specimens both rami of the accessory piece were in contact with the base of the cirrus as shown by Mizelle and Donahue (1944, Pl. 2, Figs. 64, 65). In other cases only one ramus was so connected, and in some specimens

both rami of the accessory piece were obviously free from the base of the cirrus. It is quite possible that one or both rami articulate with the cirrus base and that they become detached therefrom during preparation of specimens for microscopic study. For the present this species is being retained in the genus *Urocleidus* Mueller, 1934, pending further study. Should the cirrus and accessory piece be articulated in this species, it should be removed to the genus *Cleidodiscus* Mueller, 1934.

The posterior eye spots of this species are larger and generally closer together than those of the anterior pair. A variation in the shape of the ventral bar consists of a slender structure with the terminal portions recurved (Pl. 1, Fig. 75). The measurements in the present investigation are given together with those of the redescription (in quotation marks) for the purposes of comparison. Original measurements (Mueller 1936) are given in the redescription (Mizelle and Donahue 1944). Length 0.527 mm. (0.432-0.594 mm.) "0.357 mm. (0.214-0.614 mm.)," greatest body width 0.130 mm. (0.103-0.163 mm.) "0.136 mm. (0.087-0.186 mm.)." Transverse diameter of pharynx 0.044 mm. (0.041-0.047 mm.) "0.044 mm. (0.038-0.052 mm.)." Haptor width (greatest) 0.111 mm. (0.073-0.146 mm.), length 0.074 mm. (0.065-0.099 mm.); haptoral dimensions were not given in the redescription. Ventral anchor length 0.047 mm. (0.041-0.052 mm.) "0.048 mm. (0.041-0.055 mm.)," greatest width of base 0.030 mm. (0.027-0.034 mm.) "0.034 mm. (0.025-0.036 mm.)"; dorsal anchor length 0.042 mm. (0.034-0.047 mm.) "0.046 mm. (0.032-0.052 mm.)," greatest width of base 0.026 mm. (0.022-0.028 mm.) "0.032 mm. (0.025-0.036 mm.)." Ventral bar length 0.036 mm. (0.034-0.040 mm.) "0.043 mm. (0.038-0.046 mm.)"; dorsal bar length 0.039 mm. (0.036-0.043 mm.) "0.041 mm. (0.036-0.044 mm.)." Hook lengths 0.016-0.022 mm. "0.015-0.022 mm." The hooks of this species are figured herein (Pl. 1, Figs. 76, 77) for the first time. This species like *Tetraonchus monenteron* and *Urocleidus aculeatus* is found on only one host and is the only species of Tetraonchinae recorded from its particular host (yellow perch).

UROCLEIDUS CHAUTAUQUENSIS (Mueller, 1938) Mizelle and Hughes, 1938
Pl. 2, Figs. 1-9

Synonym.—*Tetracleidus chautauquensis* Mueller, 1938; *Cleidodiscus chautauquensis* Mueller, 1938.

Host and Locality.—Rock Bass *Ambloplites rupestris,* Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis.

Previously Reported Host and Locality.—Rock Bass *Ambloplites rupestris,* Chautauqua Lake, N. Y. (Mueller 1938).

Specimens Studied.—Three.

Redescription.—Moderately small dactylogyrids with a smooth cuticula. Length 0.624 mm. (0.531-0.684 mm.), greatest body width 0.109 mm. (0.090-0.124 mm.) "about 1 mm. in length by 0.2 mm. in width." Cephalic lobes moderate to small; members of the posterior pair of eye spots much larger and further apart or closer together than those of the anterior pair. Pharynx circular in outline (dorsal view) and 0.047 mm. (0.041-0.049 mm.) in trans-

verse diameter. Haptor ovate in side and dorsal views except for the portion which unites with the peduncle "wedge shaped." Haptor width 0.077 mm., haptor length 0.076 mm. (0.069-0.082 mm.). Anchors similar in shape, subequal in size (ventrals larger) and composed of 1) wide bifurcate bases (superficial root longest), 2) relatively short shafts (ventrals hollow, dorsals solid), and 3) solid points which are almost straight and unite with the shafts without formation of a definite angle (Pl. 2, Fig. 5 and Mueller 1938, Pl. 2, Figs. 10, 11). Length of ventral anchor 0.033 mm. (0.032-0.035 mm.), greatest width of base 0.016 mm. (0.014-0.018 mm.); length of dorsal anchor 0.031 mm., greatest width of base 0.013 mm. "Anchors 0.04 mm. in greatest straight dimension." Haptoral bars different in shape, ventral with uneven margins and usually with a median spine on the posterior border (Pl. 2, Figs. 6, 7 and Mueller 1938, Pl. 2, Figs. 15-16). Ventral bar length 0.022 mm., dorsal bar length 0.023 mm. "about equal in size, 0.023 mm. long." Hooks fourteen in number, arrangement normal (Mizelle 1938) with members of pair number five (seven of Mueller) situated between the ventral anchor shafts. Each hook is composed of a base, a shaft, a sickle-shaped termination and an opposable piece (Pl. 2, Figs. 8, 9). Posteriorly projecting structure of hook not observed for this species. The bases of the hooks of pair number five are solid and elliptical in outline and shorter than their respective shafts whereas the bases of the rest of the hooks appear hollow and are longer than their respective shafts. Length of hooks of pair number five 0.011-0.015 mm., lengths of remaining hooks 0.023-0.029 mm. "0.03 mm. in length." The original author did not observe hooks of pair number five (seven of Mueller). Vagina present about midway the body length and opening on the right ventral margin "left margin." Seminal vesicle and seminal receptacle relatively large, the former ovate in outline (dorsal view) and the latter globular. Prostate glands not observed. Gonads situated in the posterior body half, ovate in outline (dorsal view), subequal in size; testis posterior. Copulatory complex composed of an elongate tubular cirrus and a solid accessory piece. A thread-like structure is wound around the cirrus shaft for most of its length (Pl. 2, Figs. 3, 4 and Mueller 1938, Pl. 2, Fig. 12). Cirrus length 0.066 mm., accessory piece length 0.034 mm. (0.031-0.036 mm.). Vitellaria well developed and usually extend from the posterior border of the pharynx to the peduncle. In one specimen these structures were observed to extend from the anterior level of the pharynx into the proximal half of the haptor.

UROCLEIDUS DISPAR (Mueller, 1936) Mizelle and Hughes, 1938

Synonyms.—*Onchocleidus dispar* Mueller, 1936; *Haplocleidus dispar* (Mueller, 1936) Mueller, 1937.

Host and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Chetac Lake near Birchwood, Wis. and Bass Lake (Hatchery) near Woodruff, Wis.

Previously Reported Hosts and Localities.—Pumpkinseed Sunfish *Lepomis gibbosus,* Constantia, N. Y. (Mueller 1936), Long, Opeongo, and Proulx Lakes (all) in Algonquin Park, Ontario, Can. (Mizelle and Donahue 1944). Bluegill Sunfish *Lepomis macrochirus,* Local Ponds and Streams

near Stillwater, Okla. (Seamster 1938), Various Localities in Illinois (Mizelle 1938). Orange-spotted Sunfish *Lepomis humilis,* Local Ponds and Streams near Stillwater, Okla. (Seamster 1938). Large-Mouth Bass *Huro salmoides,* Reelfot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943).

Specimens Studied.—Two.

The two specimens of this species available in the present work present nothing new with reference to the original description (Mueller 1936) and the corrections or possibly variations noted by Mizelle and Cronin (1943) and Mizelle and Donahue (1944). The great size discrepancy of the dorsal and ventral pairs of anchors, the absence of a vagina, together with the "sculptured" cirus (cirral thread effect) and the terminally bifurcate or "keyholed" accessory piece make the identity of this species certain.

UROCLEIDUS FEROX Mueller, 1934

Synonyms.—*Onchocleidus ferox* (Mueller, 1934) Mueller, 1936; *Onchocleidus mucronatus* Mizelle, 1936; *Urocleidus mucronatus* Seamster, 1938.

Host and Localities.—Bluegill Sunfish *Lepomis macrochirus,* Bass Lake (Hatchery), Carrol Lake, Madeline Lake, and Minocqua Thoroughfare along Woodruff Hatchery (all) near Woodruff, Wis., Chetac Lake near Birchwood, Wis., and Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis.

Previously Reported Hosts and Localities.—Pumpkinseed Sunfish *Lepomis gibbosus* Oneida Lake, N. Y. (Mueller 1934), Constantia, N. Y. (Mueller 1936), Lake Senachwine, Henry, Ill. (Mizelle 1936). Bluegill Sunfish *Lepomis macrochirus,* Lake Decatur, Decatur, Ill., State Natural History Survey Pond, Urbana, Ill., Lake Senachwine, Henry, Ill., (Mizelle 1936), Boomer Creek, Stillwater, Okla. (Mizelle 1938), Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), Baton Rouge and New Roads, La. (Summers and Bennett 1938), Reelfoot Lake, Tiptonville, (Ridgely), Tenn., Lake Okeechobee, Moore Haven, Fla. (Mizelle and Brennan 1942). Orange-Spotted Sunfish *Lepomis humilis,* Lake Senachwine, Henry, Ill., Salt Fork of the Big Vermilion River, Homer, Ill. (Mizelle 1936), Local Ponds and Streams near Stillwater, Okla. (Seamster 1938). Hybrids (Orange-Spotted X Pumpkinseed and Bluegill X Pumpkinseed Sunfishes), Lake Senachwine, Henry, Ill. (Mizelle 1936).

Specimens Studied.—Nineteen.

Past information regarding this species was summarized by Mizelle and Donahue (1944). These authors suggested that (for a more complete picture) the description of this form under the synonym of *Onchocleidus mucronatus* Mizelle, 1938, probably should be consulted rather than the original description because of the free use of specimens therein (twenty), and mistakes and omissions in the original. Measurements of the Wisconsin specimens in most cases, do not represent new minima or maxima in regard to the description referred to above (*O. mucronatus*) but nevertheless are given for reasons of comparison. Body length 0.510 mm. (0.360-0.612 mm.) "0.503 mm. (0.426-0.820 mm.)," greatest body width 0.073 mm. (0.047-0.108 mm.)

"0.065 mm. (0.051-0.131 mm.)." Transverse diameter of pharynx 0.025 mm. (0.022-0.029 mm.) "0.027 mm. (0.024-0.039 mm.)." Haptor width 0.091 mm. (0.060-0.108 mm.) "0.101 mm. (0.070-0.148 mm.)," length 0.093 mm. (0.082-0.120 mm.) "0.98 mm. (0.076-0.139 mm.). Ventral anchor length 0.059 mm. (0.045-0.068 mm.) "0.057 mm. (0.051-0.067 mm.)," greatest width of base 0.017 mm. (0.013-0.020 mm.) "0.014 mm. (0.009-0.019 mm.)"; length of dorsal anchors 0.056 mm. (0.045-0.063 mm.) "0.057 mm. (0.051-0.074 mm.)," greatest width of base 0.014 mm. (0.011-0.018 mm.) "0.012 mm. (0.09-0.019 mm.)." Ventral bar length 0.023 mm. (0.020-0.025 mm.) "0.022 mm. (0.019-0.024 mm.)," length of dorsal bar 0.025 mm. (0.020-0.031 mm.) "0.024 mm. (0.021-0.025 mm.)." Hook lengths (except those of pair No. 5) 0.025-0.040 mm. "0.023-0.044 mm.," length of hooks of pair number 5, 0.011-0.018 mm. "0.010-0.015 mm." Cirrus and accessory piece lengths 0.043 mm. (0.032-0.049 mm.) "0.051 mm. (0.043-0.060 mm.)" and 0.023 mm. (0.018-0.029 mm.) "0.027 mm. (0.022-0.031 mm.)" respectively. The last two sets of measurements in quotation marks are from Mizelle and Brennan (1942). These structures were measured with difficulty because they (cirrus especially) are generally presented at an angle rather than in flat view. Qualitatively the present specimens offer nothing new with reference to those used in the description of *Onchocleidus mucronatus* Mizelle, 1936. As a possible exception to this statement is the possession of bases by members of hook pair number five, which in outline, vary from a circle to an ellipse. The cirrus may be straight or undulate and at times the cirral thread which is usually evident may be so inconspicuous as to appear absent. For a comparison of specimens from Tennessee and Florida with those from Illinois, see Mizelle and Brennan (1942).

UROCLEIDUS FURCATUS (Mueller, 1937) Mizelle and Hughes, 1938

Pl. 2, Figs. 10, 11

Synonym.—*Haplocleidus furcatus* Mueller, 1937.

Host and Localities.—Large-Mouth Bass *Huro salmoides,* Chetac Lake near Birchwood, Wis., and Bass Lake (Hatchery) near Woodruff, Wis.

Previously Reported Hosts and Localities.—Large-Mouth Bass *Huro salmoides,* Various Localities, Fla. (Mueller 1937), Baton Rouge, La. (Summers and Bennett 1938), Hatchery, Norris, Tenn. (Mizelle 1940). Kentucky or Spotted Bass *Micropterus punctulatus,* Norris Lake, Norris, Tenn., Cold Creek below Norris Dam (Tenn.) (Mizelle 1940).

Specimens Studied.—Fourteen.

This species originally described (Mueller 1937) from the large-mouth bass (*Huro salmoides*) taken from Florida localities was redescribed (Mizelle 1940) on the basis of ten specimens from this same host and the Kentucky or spotted bass (*Micropterus punctulatus*) from Tennessee waters. Very few of the measurements from the Wisconsin material lie outside the limits recorded for corresponding ones in the redescription, as shown below. The four measurements presented in the original description are reproduced in the redescription. Length 0.383 mm. (0.252-0.522 mm.) "0.352 mm. (0.238-

0.495 mm.)," greatest body width 0.104 mm. (0.082-0.129 mm.) "0.107 mm. (0.081-0.135 mm.)." Transverse diameter or pharynx 0.027 mm. (0.023-0.031 mm.) "0.025 mm. (0.022-0.030 mm.)," Haptoral width 0.085 mm. (0.073-0.090 mm.) "0.082 mm. (.068-0.091 mm.)," length 0.080 mm. (0.065-0.090 mm.) "0.067 mm. (0.058-0.82 mm.)." Ventral anchor length 0.037 mm. (0.029-0.040 mm.) "0.035 mm. (0.025-0.038 mm.)," greatest width of base 0.016 mm. (0.013-0.018 mm.) "0.015 mm. (0.011-0.018 mm.)"; dorsal anchor length 0.071 mm. (0.045-0.079 mm.) "0.074 mm. (0.043-0.081 mm.)," greatest width of base 0.023 mm. (0.018-0.029 mm.) "0.015 mm. (0.014-0.016 mm.). Ventral bar length 0.025 mm. (0.023-0.026 mm.) "0.028 mm. (0.025-0.032 mm.)," dorsal bar length 0.038 mm. (0.036-0.040 mm.) "0.030 mm. (0.020-0.037 mm.)." Cirrus length 0.065 mm. (0.059-0.069 mm.) "0.064 mm. (0.062-0.066 mm.)," accessory piece length 0.038 mm. (0.027-0.040 mm.) "0.032 mm. (0.020-0.038 mm.)." Hook lengths 0.013-0.023 mm. "0.011-0.026 mm." The ventral bar in the present specimens in side view, appears to possess a median spine on the posterior border (Pl. 2, Fig. 11) which in flat view is apparently a broad but very thin plate-like structure (Pl. 2, Fig. 10). A botuliform prostate gland filled with a coarsely granular hyaline material was observed near the elongate seminal vesicle. In some cases the anterior eye spots were farther apart than those of the posterior pair in contrast to their being invariably closer together as reported in the redescription.

UROCLEIDUS HELICIS (Mueller, 1936) Mizelle and Hughes, 1938

Pl. 1, Figs. 56, 67

Synonym.—*Onchocleidus helicis* Mueller, 1936.

Host and Localities.—Pumpkinseed Sunfish *Lepomis gibbosus*, Bullhead Lake near Minocqua, Wis. and Minocqua Thoroughfare along Woodruff Hatchery near Woodruff, Wis.

Previously Reported Host and Locality.—Large-Mouth Bass *Huro salmoides*, Cross Lake, N. Y. (Mueller 1936).

Specimens Studied.—Two.

From the above information it is observed that the two specimens used herein were taken from the common sunfish whereas the original description was made on material from the large-mouth bass. This is very striking for in only one other case (*U. dispar*, Mizelle and Cronin 1943) have these two hosts been recorded to harbor the same species of dactylogyrid parasite. Both cases probably represent ectopic conditions. *Urocleidus helicis* is a small trematode 0.234-0.306 mm. "0.3 mm." long and 0 077-0.095 mm. in greatest body width. The body shape is typical; cephalic lobes moderate in size; eye spots four in number with members of the posterior pair larger and closer together than those of the anterior pair. Pharynx ovate in outline (dorsal view) and 0.022-0.027 mm. in transverse diameter "0.028 mm. in diameter." Peduncle short; haptor hexagonal in outline, length 0.060-0.064 mm. "0.06 mm.," width 0.107 mm. "0.09 mm." Dorsal bar with a median spine on the posterior border (Pl. 1, Fig. 66), dorsal bar length 0.040 mm.; ventral bar with the median posterior surface drawn out to form a wide process

(Pl. 1, Fig. 67), ventral bar length 0.038 mm. "bars long, about 0.045 by 0.007 mm." Anchors similar in shape, subequal in size, and with well-developed bases and long slender solid shafts and points. Anchor wings conspicuous only on the ventral anchor shafts (Pl. 1, Fig. 64). Ventral anchor length 0.041-0.043 mm., greatest width of base 0.016-0.017 mm.; dorsal anchor length 0.036-0.041 mm., greatest width of the base 0.011-0.015 mm. "Anchors 0.05 mm. in greatest dimensions." Hooks fourteen in number and normal in arrangement (Mizelle 1938) with members of pair number five (seven of Mueller) situated between the ventral anchor shafts. Each hook is differentiated into a base, a shaft, a sickle-shaped termination, and an opposable piece (Pl. 1, Figs. 58-63). A posteriorly projecting structure arises from the sickle-shaped termination and apparently serves for muscular attachment. The bases of the hooks are elliptical in outline and are about as long as the hook shafts in members of all pairs except those of number five in which they are shorter than the shafts. Hook lengths (except those of pair No. 5) 0.020-0.023 mm., length of hooks of pair number five 0.014-0.016 mm. Copulatory complex consisting of a corkscrew-like cirrus and an accessory piece with a distal bifurcation (Pl. 1, Figs. 56, 57). Cirrus length 0.036-0.041 mm. "about 0.055 mm. long," accessory piece length 0.027-0.029 mm. Vagina situated on the right body margin about midway the length and connected to the seminal receptacle by a relatively long vaginal tube. Gonads, seminal vesicle, and prostates not observed. Vitellaria moderate in development and extend from the posterior border of the pharynx to the peduncle.

UROCLEIDUS PRINCIPALIS (Mizelle, 1936) Mizelle and Hughes, 1938
Pl. 2, Figs. 12-14

Synonym.—*Onchocleidus principalis* Mizelle, 1936; *Onchocleidus contortus* Mueller, 1937.

Host and Localities.—Large-Mouth Bass *Huro salmoides,* Bass Lake (Hatchery) near Woodruff, Wis. and Chetac Lake near Birchwood, Wis.

Previously Reported Hosts and Localities.—Kentucky or Spotted Bass *Micropterus punctulatus,* Salt Fork of the Big Vermilion River, Homer, Ill. (Mizelle 1936), Cove Creek, Caryville, Tenn., Norris Lake, Norris, Tenn., Cold Creek below Norris Dam (Tenn.) (Mizelle 1940). Small-Mouth Bass *Micropterus dolomieu,* Local Ponds and Streams near Stillwater, Okla. (Seamster 1938), Salt Fork of the Big Vermilion River, Homer, Ill. (Mizelle 1938), Cove Creek, Caryville, Tenn. (Mizelle 1940). Large-Mouth Bass *Huro salmoides,* Fla. (Mueller 1937), Baton Rouge, La. (Summers and Bennett 1938), Lake Senachwine, Henry, Ill. (Mizelle 1938), Hatchery, Norris, Tenn. (Mizelle 1940), Reelfoot Lake, Tiptonville (Ridgely), Tenn. (Mizelle and Cronin 1943).

Specimens Studied.—Eight.

Comparative Description.—The original description of this species was based on twenty specimens obtained from the Kentucky or spotted bass (*Micropterus punctulatus*) from the Salt Fork of the Big Vermilion River near Homer, Ill. In 1940 Mizelle measured ten specimens recovered from

the Kentucky (*Micropterus punctulatus*), large-mouth (*Huro salmoides*), and small-mouth (*Micropterus dolomieu*) basses taken from Tennessee localities. Measurements were compared for the specimens from the two localities and it was found that the northern specimens were not only larger but all except three of the various other measurements were as great or greater than corresponding ones for the Tennessee forms. It was also noted that there were size discrepancies with reference to specimens from a given host species but the number of specimens involved were too small to make a conclusive statement in this regard.

The eight specimens available in this study are interesting in that they average smaller than those used in the original description, and are larger than the four specimens from the same host from Tennessee. Measurements have not been taken on specimens from the large-mouth bass from Illinois or other localities of a comparable latitude. The following are measurements of present and Illinois specimens (Mizelle 1936, 1938): length 0.335 mm. (0.270-0.396 mm.) "0.467 mm. (0.369-0.631 mm.)," greatest body width 0.088 mm. (0.073-0.109 mm.) "0.096 mm. (0.070-0.127 mm.)," transverse diameter of pharynx 0.028 mm. (0.023-0.035 mm.) "0.029 mm. (0.025-0.034 mm.)," length of haptor 0.066 mm. (0.056-0.073 mm.) "0.066 mm. (0.051-0.082 mm.)," width of haptor 0.077 mm. (0.073-0.086 mm.) "0.098 mm. (0.078-0.125 mm.)," length of ventral anchors 0.041 mm. (0.036-0.045 mm.) "0.033 mm. (0.028-0.038 mm.)," greatest width of ventral anchor bases 0.018 mm. (0.014-0.020 mm.) "0.018 mm. (0.015-0.021 mm.)," length of dorsal anchors 0.038 mm. (0.031-0.040 mm.) "0.031 mm. (0.027-0.034 mm.)," greatest width of dorsal anchor bases 0.015 mm. (0.014-0.016 mm.) "0.015 mm. (0.013-017 mm.)," length of ventral bar 0.035 mm. (0.032-0.036 mm.) "0.036 mm. (0.032-0.042 mm.)," length of dorsal bar 0.033 mm. (0.030-0.036 mm.) "0.035 mm. (0.030-0.044 mm.)," hook lengths 0.013-0.023 mm. "0.013-0.025 mm." The cirrus and accessory piece could not be accurately measured in the specimens at hand because of unfavorable orientation nor were they measured in the Illinois specimens. Qualitatively it was noted in the Wisconsin specimens that 1) the vagina opens toward the dorsal side of the right lateral body margin, 2) the posterior border of the ventral bar is developed to present a second margin which appears as a spine-like structure when viewed from one side (Pl. 2, Figs. 13, 14), 3) the shaft of each ventral anchor infrequently is noticeably bent in the directon of the points, (Pl. 2, Fig. 12), 4) the anchor wings on each ventral anchor shaft are larger than that on the dorsal anchors, and 5) the union of the anchor points and shafts are not as smooth as indicated in the original description (Pl. 2, Fig. 12, and Mizelle 1938, Pl. 4, Figs. 76, 77).

TETRAONCHUS MONENTERON (Wagener, 1857) Diesing, 1858
Pl. 2, Figs. 32-45

Synonyms.—*Dactylogyrus monenteron* Wagener, 1857; *Gyrodactylus cochlea* Wedl, 1857; *Monocoelium monenteron* (Wagener, 1857) Wegener, 1909; *Ancyrocephalus monenteron* Lühe, 1909.

Host and Localities.—Northern Pike *Esox lucius,* Yellow River Flowage next to Fisheries Laboratory near Spooner, Wis. and Thoroughfare along Woodruff Hatchery near Woodruff, Wis.

Previously Reported Host and Localities.—Northern Pike *Esox lucius,* Various Localities in Europe (Wagener 1857, Wedl 1858, Parona and Perugia 1890, Olsson 1893, etc.), Oneida Lake, N. Y. (Van Cleave and Mueller 1934).

Specimens Studied.—Twenty.

Redescription.—Moderate-sized Tetraonchinae, length 0.774 mm. (0.576-1.170 mm.) "about 0.85 mm. long" (Van Cleave and Mueller 1934); greatest body width which may occur in the middle or in the anterior or posterior half of the specimens, 0.131 mm. (0.086-0.215 mm.). In many cases preserved specimens were constricted in the mid-portion of the body. Cephalic lobes well developed and two in number; eye spots four, with members of the posterior pair larger and closer together (infrequently contiguous) than members of the anterior pair. Pharynx ovate in outline (dorsal view), transverse diameter 0.047 mm. (0.036-0.072 mm.). Peduncle moderate in size; haptor roughly semicircular in outline (dorsal view), haptor width 0.163 mm. (0.129-0.206 mm.), haptor length 0.073 mm. (0.056-0.086 mm.). The single haptoral bar (ventral) is of a bow shape, cavernous, and has thickened margins, length 0.069 mm. (0.060-0.082 mm.) (Pl. 2, Fig. 41). Apparently the dorsal bar has disappeared during the evolution of this species as have the ventral anchors and in some cases, the ventral bar in members of the genus *Dactylogyrus.* The two pairs of anchors possess large bases which present open cavities (Pl. 2, Figs. 42, 43; Van Cleave and Mueller 1934, Pl. 28, Fig. 1; Wedl 1858, Pl. 3, Fig. 37; Wagener 1857, Pl. 13, Fig. 3). Anchor shafts and points solid and unite rather smoothly. Ventral anchor length 0.090 mm. (0.075-0.099 mm.), greatest width of base 0.039 mm. (0.030-0.043 mm.); dorsal anchor length 0.090 mm. (0.086-0.101 mm.), greatest width of base 0.034 mm. (0.026-0.039 mm.). Anchor bases with well-developed roots; superficial root longest in dorsal anchors, deep root longest in ventral anchors. Anchor wings poorly developed. Hooks sixteen in number, subequal in size in a given specimen, and each composed of 1) only an infrequent suggestion of a base, 2) a slender shaft, 3) a sickle-shaped termination, and 4) an opposable piece which is decurved toward the hook base (Pl. 2, Figs. 44, 45); hook lengths 0.010-0.015 mm. Wagener (1857, Pl. 13, Fig. 3) in his original description of this species figured the opposable piece bent toward the distal end of the hook and Van Cleave and Mueller (1934, Pl. 28, Fig. 1) failed to show the opposable piece at all. Neither did the latter authors figure the posteriorly projecting structure which arises from the convex surface of the sickle-shaped termination of a hook and they depicted the hook shafts as being inflated whereas they are solid in the material at hand. The posteriorly projecting structure is poorly developed in the Wisconsin specimens and at times appears inflated. Five pairs of hooks are located ventrally and three pairs dorsally and not all on the ventral side of the haptor as figured by Van Cleave and Mueller (1934,

Pl. 28, Fig. 1). Hooks of pair number one are situated on the ventral surface of the haptor anterior to the ventral bar. Those of pairs two, three, and five are also ventrally located, near the lateral margin of the haptor, number two being the most anterior. Hooks of pair number four are marginal and lie between and somewhat below members of pairs numbers three and five. Hooks of pair number six are located on the posterior edge of the haptor behind and at approximately the same level as the dorsal anchors. Those of pairs numbers seven and eight lie on the dorsal side of the haptor, number eight being the more anterior. This system of numbering which begins with the anterior central hook on the ventral surface and progresses posteriorly on the ventral side of the haptor and then goes anteriorly on the dorsal side of the haptor, was proposed by Mizelle in 1938 and has been successfully used by this author and his students. Gonads ovate in outline, located near the mid-length of the body, subequal in size, and with the testis situated immediately behind and frequently overlapping the posterior margin of the ovary. Seminal receptacle, vagina, and intestine not observed. Seminal vesicle bulb-shaped and of moderate size. Copulatory complex composed of a cirrus, length 0.027 mm. (0.025-0.031 mm.), and an accessory piece, length 0.025 mm. (0.023-0.027 mm.), with the latter coiled about the cirrus in one portion (Pl. 2, Figs. 33, 37). The copulatory complex as observed herein does not closely resemble that shown by Wagener, Pl. 2, Figs. 32, 36 (reproduced from Wagener 1857, Pl. 13, Fig. 1) nor that drawn by Wegener, Pl. 2, Figs. 35, 39 (reproduced from Wegener 1909, Fig. 7) nor that illustrated by Van Cleave and Mueller, Pl. 2, Fig. 40 (reproduced from Van Cleave and Mueller 1934, Pl. 28, Fig. 1) but does closely resemble that depicted by Wedl, Pl. 2, Figs. 34, 38 (reproduced from Wedl 1858, Pl. 3, Fig. 36). The copulatory complex in the present specimens differs from that of the original description, in part, by the presence of a longer cirrus and, in part, from that figured by Van Cleave and Mueller in that the cirrus and accessory piece do not arise from a common base but are distinct structures which are intimately associated. Wedl did an admirable representation of these structures considering what his microscopic equipment must have been. The highly accurate figure of the latter author and the fact that only one species of Tetraonchinae has been recorded for *Esox lucius*, together with the unmistakable haptoral armament depicted by all the above authors make it very clear that the copulatory complex was misrepresented by Wagener, Wegener, and Van Cleave and Mueller. No measurements were given in the original description (1857) and only one (body length) in the work of Van Cleave and Mueller (1934). Measurements of European authors are not included herein.

Dactylogyrus eucalius n. sp.

Pl. 2, Figs. 46-61

Host and Locality.—Brook Stickleback *Eucalia inconstans*, Brule Hatchery Pond near Brule, Wis.

Specimens Studied.—Fifteen.

Type Specimens.—Cotypes, Univ. Notre Dame Type Collection, Notre Dame, Indiana.

Description.—Relatively small dactylogyrids which infrequently show local thickenings of the cuticula, body length 0.288 mm. (0.180-0.360 mm.), greatest body width near middle of the body and measuring 0.090 mm. (0.043-0.138 mm.). Cephalic lobes small and inconspicuous, eye spots four in number with members of the posterior pair somewhat larger and usually farther apart than those of the anterior pair. Each eye spot is composed of a loose aggregation of melanistic granules which separate readily on application of pressure (cover-glass). Pharynx subcircular in outline (dorsal view) and 0.031 mm. (0.027-0.040 mm.) in transverse diameter. Peduncle of moderate dimensions, haptor well differentiated and roughly ovate to hexagonal in outline. Haptor width 0.075 mm. (0.065-0.086 mm.), haptor length 0.047 mm. 0.034-0.056 mm.). The single pair of existing anchors are dorsal in position and connected by a chitinous bar of somewhat variable shape (Pl. 2, Figs. 54-57). Each anchor is composed of a conspicuous base (superficial root longer), a solid shaft, and a solid point (Pl. 2, Figs. 52, 53). The shaft and point unite to form a slight angle in many instances while in others the union is comparatively smooth. Anchor wings variable in height, often displaced toward the concave portion of the shaft, and apparently dual in nature. Bar length 0.031 mm. (0.029-0.036 mm.). Vestigial ventral bar not observed. Anchor length 0.028 mm. (0.025-0.031 mm.), greatest width of anchor base 0.016 mm. (0.013-0.018 mm.). Haptoral hooks composed of 1) ovate bases shorter than, 2) the slender solid shafts, 3) a sickle-shaped termination, 4) an opposable piece, and 5) a posteriorly projecting structure arising from the convex surface of the sickle-shaped termination. Hook lengths 0.016-0.022 mm. Copulatory complex composed of a relatively simple cirrus and a rather complicated accessory piece which is normally articulated to the cirrus base (Pl. 2, Figs. 46, 51). Cirrus length 0.029 mm. (0.025-0.032 mm.), accessory piece length 0.022 mm. (0.020-0.024 mm.). Ovary and testis roughly ovate in outline (dorsal view) and overlapping each other to a considerable extent, ovary anterior. Digestive tract beyond pharynx, seminal receptacle, vagina, and seminal vesicle not observed. Vitellaria composed of numerous spherules distributed from the posterior border of the pharynx to the peduncle. In some specimens the vitellaria were so greatly developed that minute observation of the copulatory complex was almost impossible.

The copulatory complex of this species does not resemble closely, that of any other described member of the genus *Dactylogyrus*. The cirrus may be said to be remotely similar to that of *D. microphallus* Mueller, 1938 (Pl. 4, Fig. 12) while the accessory piece is peculiar to itself. The anchors are not greatly unlike those of *D. tenax* Mueller, 1938 (Pl. 4, Fig. 27) and the bar is somewhat similar in some instances to that of *D. photogenus* Mueller, 1938 (Pl. 4, Fig. 19). This is the only species of monogenetic fluke described from the gills of *Eucalia inconstans*.

EXPLANATION OF PLATES

PLATE 1.—All figures were made at the same magnification with the aid of a camera lucida.

Figs. 1-7. *Actinocleidus fergusoni* Mizelle, 1938.—1, Accessory piece. 2, Cirrus. 3, Anterior bar. 4, Posterior. 5, Vaginal tube. 6, 7, Hooks.

Figs. 8-11. *Actinocleidus fusiformis* (Mueller, 1934) Mueller, 1937.—8, Accessory piece. 9, Cirrus. 10, 11, Hooks (ordinary).

Figs. 12, 13. *Actinocleidus unguis* Mizelle and Cronin, 1943.—12, Anterior anchor. 13, Posterior anchor.

Figs. 14-25. *Cleidodiscus aculeatus* (Van Cleave and Mueller, 1932) new comb.—14, 15, Dorsal anchors. 16, Ventral anchor. 17-19, Hooks. 20, Dorsal bar. 21, Ventral bar. 22, 23, Accessory pieces. 24, 25, Cirri.

Figs. 26-40. *Cleidodiscus alatus* Mueller, 1938.—26, 27, Accessory pieces. 28, 29, Cirri. 30, 31, Dorsal anchors. 32, Ventral anchor. 33, Ventral bar. 34, Dorsal bar. 35, 36, Hooks (ordinary). 37, Hooks (No. 1). 38, Hooks (No. 5). 39, 40, Vaginae and vaginal canals.

Figs. 41-50. *Cleidodiscus capax* Mizelle, 1936.—41, Accessory piece. 42, Cirrus. 43, Dorsal anchor. 44, Ventral anchor. 45, 46, Dorsal bar. 47, Ventral bar. 48-50, Hooks.

Figs. 51-55. *Cleidodiscus pricei* Mueller, 1936.—51, 52, Dorsal bars. 53, Hooks (No.5). 54, 55, Hooks (ordinary).

Figs. 56-67. *Urocleidus helicis* (Mueller, 1936) Mizelle and Hughes, 1938.—56, Accessory piece. 57, Cirrus. 58-60, Hooks (ordinary). 61-63, Hooks (No. 5). 64, Ventral anchor. 65, Dorsal anchor. 66, Dorsal bar. 67, Ventral bar.

Figs. 68-72. *Urocleidus acer* (Mueller, 1936) Mizelle and Hughes, 1938.—68, 69, Cirri. 70, 71, Hooks (ordinary). 72, Hook (No. 5).

Figs. 73-77. *Urocleidus adspectus* Mueller, 1936.—73, Accessory piece. 74, Cirrus. 75, Ventral bar. 76, 77, Hooks.

PLATE 2.—All figures were made at the same magnification with the aid of a camera lucida, except those of *Tetraonchus monenteron* which were reproduced from previous publications.

Figs. 1-9. *Urocleidus chautauquensis*.—1, 2, Accessory pieces. 3, 4, Cirri. 5, Ventral anchor. 6, 7, Ventral bar. 8, Hook (No. 5). 9, Hook (ordinary).

Figs. 10, 11. *Urocleidus furcatus* (Mueller, 1937) Mizelle and Hughes, 1938.—10, 11, Ventral bors.

Figs. 12-14. *Urocleidus principalis* (Mizelle, 1936) Mizelle and Hughes, 1938.—12, Ventral anchor. 13, 14, Ventral bars.

Figs. 15-31. *Cleidodiscus stentor* Mueller, 1937.—15, Accessory piece. 16, Cirrus. 17-19, Dorsal anchors. 20, Ventral anchors. 21-23, Dorsal bars. 24-26, Ventral bars. 27-29, Vaginae. 30, Hook (No. 5). 31, Hook (ordinary).

Figs. 32-45. *Tetraonchus monenteron* (Wagener, 1857) Diesing, 1858.—32-35, Accessory pieces. 36-39, Cirri. 40, Copulatory complex. 41, Bar. 42, Dorsal anchor. 43, Ventral anchor. 44, 45, Hooks.

Figs. 46-61. *Dactylogyrus eucalius* n. sp.—46-48, Accessory pieces. 49-51, Cirri. 52, 53, Anchors. 54-57, Bars. 58-60, Hooks. 61, Egg.

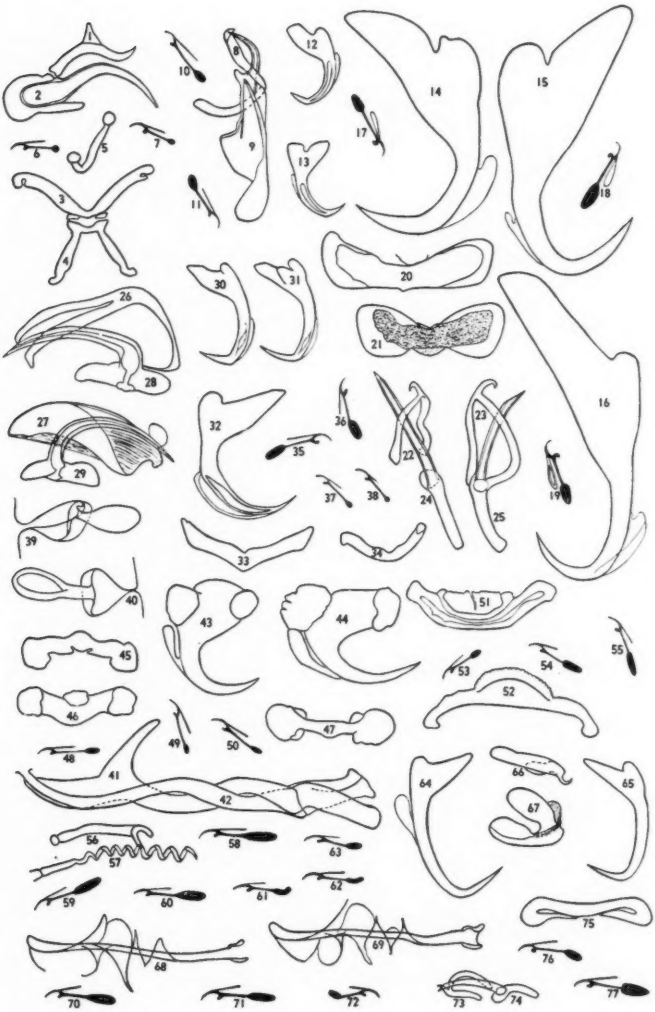
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PLATE 1

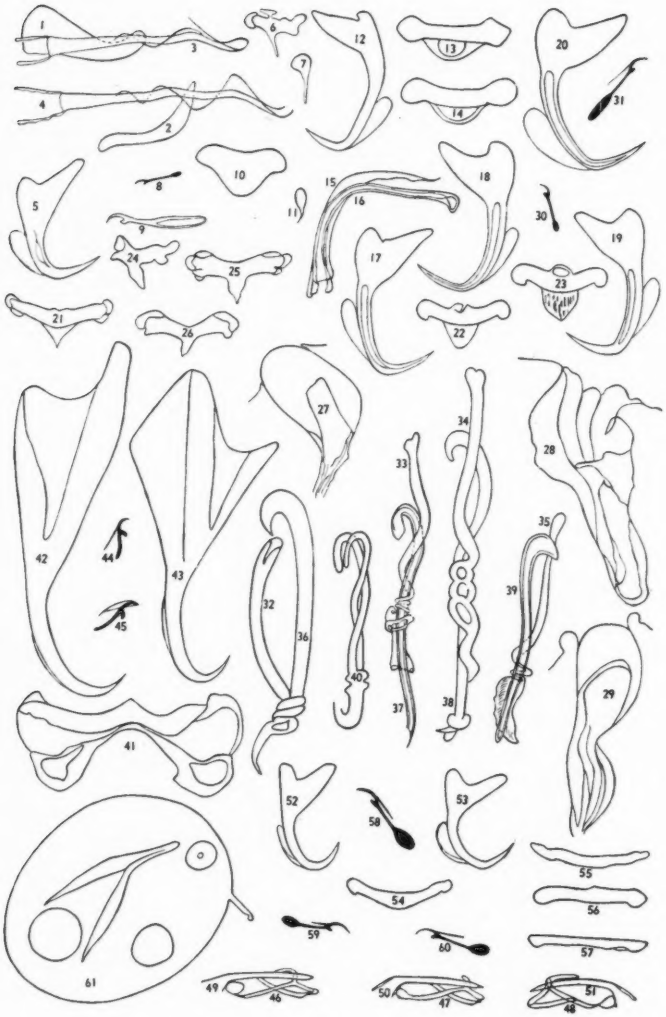
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PLATE 2

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Descriptions of Four Salientian Eggs

R. L. Livezey and A. H. Wright

There exist, so far as we know, no descriptions of the eggs of *Bufo alvarius, Rana aurora aurora, Rana boylii sierrae,* and *Rana pretiosa luteiventris.* In the collection of the Cornell University Museum there are specimens of eggs of each of these species. Unfortunately the individual eggs were not measured when freshly collected. Hence, the measurements given below were obtained from material preserved in seven per cent formalin. However, so far as can be determined, the preservative has caused no appreciable change in the specimens. The measurements were made with the aid of an ocular micrometer. Unless stated otherwise, data appearing under the sections on field notes are from the records of A. H. Wright.

Bufo alvarius Girard

History.—Eggs of *B. alvarius* have been known for some years. Ruthven (1907, p. 506) states that "with the first heavy summer showers, as a result of which water will stand in pools, these frogs appear in abundance and lay eggs which hatch very soon," and that "the eggs were laid in the clear stream of water which was perhaps a foot to eighteen inches deep." Kellogg (1932, p. 36) menions that "the eggs are laid during the first heavy summer showers in temporary pools of water or in shallow streams." A Mr. Gorsuch (Wright and Wright, 1942, p. 61) "once found several pairs of *B. alvarius* which he brought up to the station. They laid long strings of black eggs."

Field notes.—In Sabino Canyon, north of Tucson, Arizona, in the evening of July 2, 1934, numerous *B. alvarius* males were located. These toads were found jumping into the water of the pools and resting on the bank as much as thirty feet from the water's edge. Continued search was rewarded by the discovery of six to eight clasping pairs in shallow water four to eight inches in depth. Of these, three pairs were brought to the residence of Professor L. P. Wehrle and placed in a tub. By eleven o'clock that night eggs had been deposited in immense rope-like masses. By morning only one pair of toads was still mated.

Description of eggs.—Deep brown above and tan below, the eggs are encased in a single long tube of jelly. The envelope is somewhat loose, but quite distinct in outline; the gelatinous material is, for the most part, clear, transparent, and not very adhesive. There are no partitions between the individual eggs, whose arrangement varies from a perfectly linear series of near spheres to a zig-zag pattern of broadly wedge-shaped eggs. The number of eggs per inch averages eighteen (range 12 to 28). Vitelline membranes are close to the vitelli and not visible with the unaided eye; at times they are difficult to see even under 12x magnification. Measurements on the eggs are as follows: vitellus 1.4 mm. (range 1.14 to 1.70 mm.); vitelline capsule 1.6 mm. (range 1.25 to 1.70 mm.); envelope 2.2 mm. (range 2.12 to 2.25 mm.).

Affinities indicated.—Except for the deeper color of the vitelli, the lesser degree of convolution and lack of slight scalloping of the gelatinous tube, eggs of *B. alvarius* are similar to those of *B. compactilis*. Measurements of both average approximately the same in all respects. The total mass of eggs is larger in *B. alvarius* and the crowding within the tube is more intense (12 to 28 per inch for *alvarius* to 14 to 20 for *compactilis*), this difference, however, being barely noticeable.

Superficially *B. alvarius* eggs also look like those of *B. terrestris*. But here the lighter color of the eggs and greater degree of convolution of the tube plus the presence of an inner envelope serve to separate eggs of these species immediately.

RANA AURORA AURORA (Baird and Girard)

Field notes.—March 27, 1942. Between Nolan Creek and Hoh River, Washington, was found a roadside ditch at least four feet across with an abundance of vegetation; sedge clumps, beside which were egg masses of newts, were on the roadside of the ditch. Attention was called to this pond because of flat masses, containing air bubbles, at the surface of the water. These masses, some of which were six inches across, were attached to the vegetation.

In the shallow end of the ditch were found frogs' eggs quite dark in color; three fresh masses and one partial mass were seen. Vitelli were far apart in the mass, about three-quarters of an inch from each other. The fresh masses, in water about six inches deep, had a quite bluish cast. One mass was approximately eight to ten inches across, another six inches.

Another ditch was located between the Hoh and Bogachiel Rivers beside a meadow with spots of snow, and such plants as *Ledum, Vaccinium,* etc. Here were several fresh masses of *R. a. aurora* eggs. One composite mass of frogs' eggs was becoming stranded out of water. There must have been fifteen to thirty masses here in an area two by three feet. Mating congress is apparently in one place as in *R. sylvatica*. In each egg envelope was a green algal growth such as often appears in some salamander eggs.

Description of eggs.—The mosaic appearing masses are made up of large eggs with a volume of about 1.2 cc. each. The jelly is very transparent, loose, and viscid. Three envelopes are present in addition to the vitelline membrane, which is easily discernible in most cases. Although rather indistinct all envelopes can be seen without the aid of a lens when viewed in proper light.. Most difficult to make out is the middle envelope, which is the thinnest. The fairly large vitellus is black at the animal pole and creamy white at the vegetal. Measurements are: vitellus 3.04 mm. (range 2.31 to 3.56 mm.); vitelline capsule 3.28 mm. (range 2.56 to 3.87 mm.); inner envelope 5.70 mm. (range 4.0 to 6.68 mm.); middle envelope 6.80 mm. (range 6.25 to 7.93 mm.); outer envelope 11.90 mm. (range 10.0 to 14.0 mm.).

Affinities.—Several differences are noticeable between the eggs of *R. a. aurora* and its very near relation *R. a. draytonii*. In general, eggs of *R. a.*

aurora are larger; the first thing to strike the eye , the vitellus, is perceptibly greater as is the dimension of the outer envelope. The outer envelope is also less distinct in *R. a. aurora.* Vitelline membranes are more easily seen in *R. a. draytonii.* With *R. a. draytonii* the three gelatinous envelopes become progressively greater in thickness from the inner to the outer, in *R. a. aurora* the middle envelope is the thinnest. The entire egg mass of *R. a. aurora* is from two to four inches greater in diameter than that of *R. a. draytonii.*

R. a. aurora eggs somewhat resemble those of *R. sylvatica.* The looseness of the jelly and form of the mass are similar, but the lack of a middle envelope and usually smaller dimensions of individual eggs and masses readily separates *R. sylvatica* from *R. a. aurora.*

RANA BOYLII SIERRAE Camp

History.—Storer (1925, p. 265) states that "eggs obtained in Cathedral Pass, Sunrise Trail, Yosemite National Park, on July 4, 1922, by Professor Stanley B. Freeborn, prove to be approximately like those of *boylii* in the lowlands. Exact measurements are not feasible, as the material was not fixed in a manner favorable to preservation of the original size."

Field notes.—One mass of eggs was collected by Osgood R. Smith on April 23, 1942, at Convict Creek, Mono County, California, at an elevation of 7,000 feet. This clutch was attached to stems of sedge and contained about 120 eggs.

On April 22, 1942, at Sycamore Creek, Kings River, California, a frog was taken which, on April 24, 1942, laid six egg masses. These were preserved before the jelly had time to expand, consequently are much smaller than would normally be found in the natural habitat, and are therefore not suitable for measurements. These masses were made up of the following numbers of eggs: 100, 125, 253, 260, 312, and 350 (av. 233).

Description of eggs.—Mass plinth-like, about 28 x 40 mm., individual eggs one-quarter to one-half inch apart. There are besides the vitelline capsule three gelatinous envelopes, all clear and transparent. The outline of the egg is distinct and the firm jelly does not collect much debris. All envelopes are quite distinguishable in good light without a lens, as is the vitelline capsule. Least in thickness is the middle envelope, the next in thickness is the inner, being about two times the thickness of the middle, and the thickest is the outer which is approximately twice that of the inner. The vitellus is black at the animal pole and grey-tan at the vegetal. Measurements are: vitellus 2.17 mm. (range 1.81 to 2.30 mm.); vitelline capsule 2.58 mm. (range 2.25 to 2.75 mm.); inner envelope 3.93 mm. (range 3.75 to 4.81 mm.); middle envelope 4.60 mm. (range 4.25 to 5.00 mm.); outer envelope 7.19 mm. (range 6.43 to 7.87 mm.).

Measurements on the eggs preserved before they had time to attain their full size showed the vitellus to average somewhat less (av. 1.88 mm.) than the other eggs taken from natural surroundings.

Affinities.—*R. b. sierrae* eggs appear much farther apart in the mass than do those of *R. b. boylii.* The vitelline capsule is more easily seen in the eggs

of *R. b. sierrae,* and the jelly envelopes are somewhat more transparent. Eggs of *R. b. sierrae* are larger in dimensions in all three of the jelly envelopes, especially the outer, than its relative. Dimensions of the egg mass are noticeably less in *R. b. sierrae* than *R. b. boylii,* and the mass contains less than one-third of the number of eggs found in that of a *R. b. boylii* clutch.

RANA PRETIOSA LUTEIVENTRIS Thompson

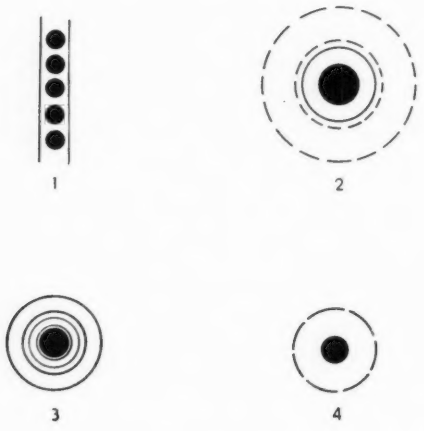
Field notes.—Lapine, Oregon, April 5, 1942. Beside the road was a shallow weedy pond from an irirgation overflow. About a foot from the edge, in water three inches deep, was a mass of frog's eggs 6 x 3½ inches; in water four inches deep was a mass 4 x 3 inches and another 3 x 3 inches.

In another pool there were three masses and, poised in the water, an adult *R. pretiosa luteiventris.* Some of these surface masses were 8 x 5 or 6 inches. One mass in shallow water was almost high and dry.

The egg masses are quite bluish and gather a considerable amount of debris.

Description of eggs.—One mass of 260 cc. volume contained about 2,400 eggs spaced one-quarter to three-quarters of an inch from each other. The jelly of the eggs is not firm thus giving the mass a loose, flowing appearance when agitated.

Only one clear transparent gelatinous envelope is present; its outline

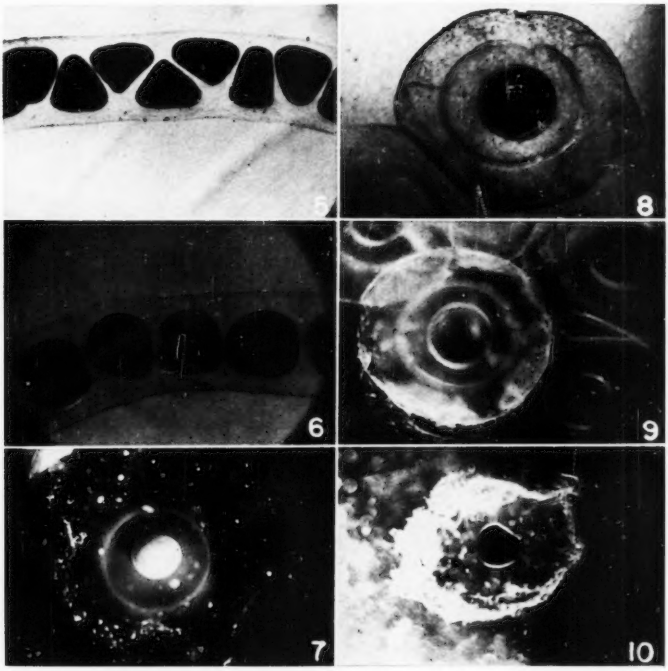


Figs. 1-4.—Diagrammatic representations of the eggs. Vitelline capsule shown only in Fig. 3. Broken lines indicate looseness of jelly and indistinctness of outline. 1. *B. alvarius.* 2. *B. a. aurora.* 3. *R. b. sierrae.* 4. *R. p. luteiventris.*

is fairly distinct, but merges slightly with the jelly of the adjacent eggs. The vitelline capsule is close to the vitellus and is seen best with the aid of a lens. The vitelli are black at the animal pole and tan at the vegetal pole.

Eggs at late cleavage to crescentic groove stage gave the following measurements: vitellus 1.97 mm. (range 1.81 to 2.12 mm.); vitelline capsule 2.06 mm. (range 1.93 to 2.25 mm.); envelope 6.33 mm. (range 5.0 to 7.12 mm.).

Affinities.—*R. p. luteiventris* eggs are much smaller in the diameter of the envelope than those of *R. p. pretiosa,* which Dickerson (1906, p. 219) gives roughly as being one-half inch across. Svihla (1935, p. 120) gives ten to fifteen millimeters as the diameter and also notes that there is an inner envelope five to six millimeters in diameter in *R. p. pretiosa* eggs. No such envelope could be demonstrated in our eggs of *R. p. luteiventris.* Sizes of the vitelli are apparently the same.



Figs. 5-10.—Microphotographs of the eggs. 5 and 6. *B. alvarius,* ×6. Vitelline capsule visible on extreme left of Fig. 6. 7. *R. a. aurora,* ×2.5. Margin of outer envelope indistinct. 8 and 9. *R. b. sierrae.* Fig. 8, ×4.5; Fig. 9, ×4. 10. *R. p. luteiventris,* ×3.

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Some Ordovician Echinoderms from Oklahoma

G. Winston Sinclair

Introduction

Some time ago Dr. Charles E. Decker sent me for examination a small collection of echinoderms from the Ordovician Bromide formation of Oklahoma. Some of these forms were of great interest, but descriptions of them were withheld until a paper which Dr. R. S. Bassler had in manuscript could be published. Since Dr. Bassler's paper has now appeared (Amer. Jour. Sci. 241:694, 1943), this contribution to our knowledge of the Bromide fauna can be offered without danger of conflict.

Our knowledge of American Ordovician echinoderms has been drawn mainly from a few classic localities: the Chazyan of the Montreal-Lake Champlain region, the Trenton of Eastern Ontario and New York, and the Eden and Maysville of Southern Ohio, with other localities contributing small numbers of species. The extent to which this distribution reflects the actual presence or absence of echinoderms in the rocks is doubtful; in some areas it must be attributed to lack of careful collecting. More than almost any other group of fossils, the echinoderms require patient and diligent search.

Bassler has described eleven cystids from the Simpson group of Oklahoma. The present paper adds two more, as well as four crinoids. It is obvious from the fragments included in Dr. Decker's material that other species await discovery and description.

The rather tangled stratigraphic history of the Bromide formation has been summarized by Loeblich (Jour. Pal. 16:413-416, 1942). In the present paper specimens are referred to the Bomide only, although Bassler has used the term Cool Creek for a portion of the formation.

I am grateful to Dr. Decker for the opportunity of studying this material, and to Mr. and Mrs. Robert W. Clarke of Montreal for the use of photographic equipment. All specimens described are in the Museum of Paleontology of the University of Oklahoma. The figured specimens of *Hybocrinus pristinus* and *Carabocrinus huronensis* are in the writer's collection.

Cystoidea

Genus Platycystites Miller

Most specimens belonging to this genus in the collection are weathered calyces which lack the arm plates on which Bassler based some of his new species. For that reason two of the identifications must be queried and regarded as probable only.

PLATYCYSTITES cf. BROMIDENSIS Bassler

Plate 1, Fig. 6

Platycystites bromidensis Bassler, Am. Jour. Sci. **241**:268, pl. 1, 10, 1943.

Description.—Theca large, circular in outline, subspherical in shape. Left arm reaching the stem; right arm shorter, extending about halfway round the side. Thecal plates very large especially on the anal side. Their exact number cannot be determined because of the imperfect condition of one side of the specimen, but the anal side shows about 17, besides 5 which lie under the left arm and are shared with the antanal side, which has about 15 other plates. The surface is not well preserved, but seems to have been minutely granular. The specimen figured (number 5008) is almost complete, but is somewhat weathered and lacks the arm plates.

The width of the arm base indicates identity with Bassler's species, which was described from fragments.

Height 36 mm.; width 35.5 mm.; thickness 26 mm.

Occurrence.—About 170 feet above the base of the Bromide formation on the West branch of Sycamore creek, Sec. 27, T. 3S, R. 4E, Okla.

PLATYCYSTITES cf. LEVATUS Bassler

Plate 1, Figs. 7-8

Platycystites levatus Bassler, Am. Jour. Sci. **241**:697, pl. 1, 13, 1943.

Description.—Theca of medium size, subovate, the two sides equally convex. Somewhat asymmetrical, more than half of the body lying to the right of a line joining anus and stem. Left arm reaching the stem; right arm short, although its exact length is not seen. About 17 thecal plates on the anal side; 5-7 common to both sides, of which 3 are ridged in the middle to form the base of the left arm plates; about 13 on the antanal side. Surface minutely granulose

Height 27 mm.; width 22 mm.; thickness 17 mm.

Occurence.—Bromide formation on the East side of U. S. highway 77, Sec. 30, T. 2S, R. 2E, Okla. The figured specimen is numbered 5009.

Remarks.—Specimens have been referred to this species because of similarity in size of the arm plates, but positive identification of both this and the preceding form must await the finding of complete thecae with arm plates in place. The variation in size of these plates in *P. bassleri* (below) throws some doubt on this feature as a diagnostic character. More material is needed to decide its validity.

This species is much smaller than *P. bromidensis* or *P. cristatus* Bassler and a little smaller than *P. fimbriatus* Bassler, in which the arm plates are much smaller. It most resembles *P. bassleri* but is smaller and more regularly ovate, and has the anus closer to the proximal end of the left arm.

Platycystites bassleri, new species

Plate 1, Fig. 1-5

Description.—Theca of medium size, subovate in outline, but strongly asymmetrical; broadly rounded and subglobose below, becoming thinner towards the sharp upper left quadrant. Anal side a little more convex than the antanal. The left arm presumably reached to the stem, but is only partially preserved. Its plates are much higher on their anal side and fold over to form a groove which faces antanally. In the flat top of the plates are excavated the brachiole facets, shallow horse-shoe shaped depressions from each of which a narrow channel leads obliquely downward and orad to the main arm groove. This groove continues past the proximal end of the arm, past a deep depression, and onto the upper surface of a sharp plate. The right arm is short (12 mm.), and seems to have had an open groove on its upper surface, with no discernible facets. This may be due to imperfect preservation, but the specimen does not seem to have been broken. The right arm groove ends in a depression under and to the antanal side of the "sharp plate" mentioned. Again there is the possibility of damage; the groove on the "sharp plate" might have continued over it to join that on the right arm, but this does not seem likely. The depression at the proximal end of either arm could be considered the mouth. The anus is situated at the junction of four plates about halfway down the right arm, and close to it. The base of the "sharp plate", on the anal side, and the adjacent edges of the two contiguous plates are raised into a trapezoid elevation on which the three sutures meet. Presumably there was a pore here of unknown function.

Thecal plates small over the stem area and rounded lower right side, larger on the rest of the body. About 16 on the anal side and 15 on the antanal, with 7 or so under the arms. The first two plates of the left arm are higher than wide, and succeeding plates are squarish and then wider than high. All plates are minutely granulose, the granules tending to be continuous and elongated near the sutures, in a direction at right angles to them.

Height 30 mm.; width 24 mm.; thickness 16 mm.

The type, number 5001, is a beautifully preserved specimen, somewhat damaged on the lower left side.

Occurrence.—Bromide formation, Sec. 27, T. 3S, R. 4E, Okla.

Hesperocystis, new genus

Genotype: *Hesperocystis deckeri*, new species.

Rhombiferous cystids of the family Cheirocrinidae; it differs from *Cheirocrinus* in having alternating brachioles rising from regular plates in a greatly expanded ambulacral area, and from *Cystoblastus* in that the thecal plates of the third series are not interpolated between those of the fourth.

This definition has been put in negative form because of difficulties offered by the unique genotype. In appearance the fossil is very similar to *Cystoblastus*, but the arrangement of its thecal plates is so different from that in normal cheirocrinids that their identification is very uncertain.

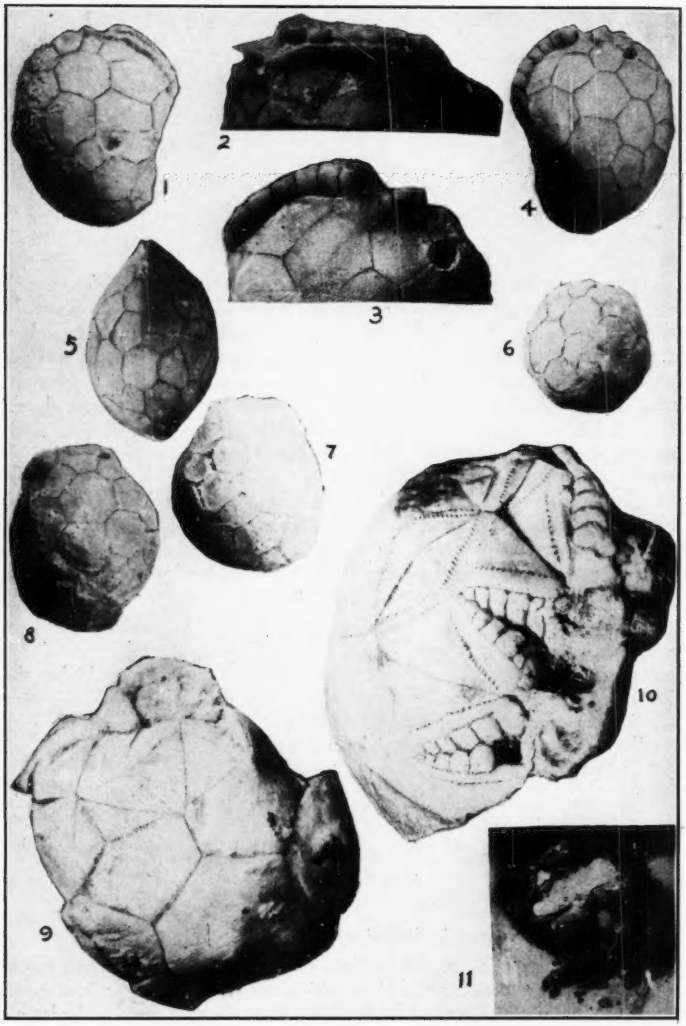

PLATE 1.—Figs. 1-5. *Platycystites bassleri*, new species. 1, antanal side; 4, anal side; 5, lower-right edge; all ×1. 2-3, antanal and anal sides of the upper margin, ×2. Fig. 6, *P.* cf. *bromidensis* Bassler. Anal side, ×0.5. Figs. 7-8. *P.* cf. *levatus* Bassler. Antanal and anal sides, ×1. Figs. 9-10, *Hesperocystis deckeri*, new species. Side and top views, ×1.5. Fig. 11, *Cheirocrinus logani* (Billings). Oral surface of a specimen from the upper Trenton at Montreal, ×2. The food groove directed toward the right is the anterior. The right-anterior and right-posterior grooves are buried in the matrix at the bottom of the figure.

The typical cheirocrinid (Bather, Trans. Royal Soc. Edinburgh 49:429, 1913) has a theca made up of plates arranged in five series: a basal circlet of four plates (1-4), two series of five plates each (5-14), another series of five plates which bear the distal ends of the food grooves (15-19), and a final series of 5 small interradial deltoids (20-24). The periproct lies between plates 7 and 8 of the second series and plate 13 of the third. In *Cheirocrinus* the periproct is greatly enlarged, so that it is also bounded by plates 12 and 14, and the thecal plates are displaced to make room for it. In *Cheirocrinus*, moreover, the deltoids are rather large, and between them are wide grooves with small regular covering plates. These grooves lead to the radials where brachioles arise in close groups from small facets on the upper edge of the plate. The oral surface in general is flat, and at right angles to the straight sides of the cylindrical theca. (See plate 1, figure 11.)

In *Cystoblastus* (Jaekel, Stammesgeschichte der Pelmatozoen: 223, 1899) the periproct remains small, but the third series is reduced to 4 large triangular plates which lie between the radials and extend upward to the proximal ends of the ambulacra to meet the deltoids. The ambulacra are very large and extend three-quarters the length of the radials.

The differences between these genera and *Hesperocystis deckeri* will be apparent in the description of the latter.

Hesperocystis deckeri, new species

Plate 1, Figs. 9-10; text fig. 1

Description.—The only specimen (number 5002) is a fragment consisting of eleven associated thecal plates and four ambulacra. The latter are large, wide and even with the surface of the radials; each consists of 11-12 quadrangular plates arranged alternately in two rows. The inner edges of these plates meet to form a wide zigzag groove. The brachiole facets are very obscure, being slightly impressed on the plates; each has an obscure depression running obliquely orad to the shallow groove separating each pair of plates on the same side. Each plate has the outer-distal corner cut off by a curved suture. It is interesting to note that in *Cystoblastus* the ambulacral plates are similarly divided, but in that genus it is the outer-proximal corner which is cut off. Several small irregular plates are displaced at the inner end of one of the ambulacra, but their original position cannot be determined. It seems probable that there were small covering plates on the food grooves.

The thecal plates present more difficulty. The well-preserved side of the specimen has three ambulacra, and no periproct is showing. The radials therefore should be 15, 16 and 17, but below plate 17 a large octagonal plate rests directly on a small plate which must be a basal. Since the plates cannot now be correlated with the standard scheme, they are simply described as they appear in the specimen (Fig. 1). Of the three radials seen, that on the right is almost twice as long as the other two, and abuts on three lower plates. It shares one of these with the central radial, which rests on this plate alone. The left radial, so far as is seen, also rests directly on one lower plate. These two sub-

radial plates rest on a smaller wide hexagonal plate. The latter, with the large plate underlying the right radial, rests on a small pentagonal basal. The rest of the right subradial rests on another similar basal. It has been mentioned

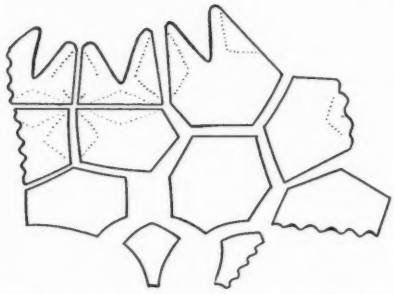

Fig. 1. *Hesperocystis deckeri;* diagram of thecal plates. The proportions are not exact. The dotted lines indicate the position of the pore rhombs, but the individual dots are not meant to represent actual slits.

that the right radial abuts on three plates. Below the largest of these and the plate on the lower right lies another hexagonal plate, which is supported in part by the second basal.

The radials are contiguous and there is a pore rhomb on the suture joining each. Rhombs are also shared by the left and central radials and their inferior plates, which latter also bears a rhomb on their joint suture. The plate at the lower right edge of the right radial has a rhomb on its right edge, but its opposite half is not seen. All the rhombs are widely disjunct. The pore openings are small and usually numerous, although the rhomb between the left and central radials has only three slits on its lower half. The plates are smooth and quite convex, with a slight humping near their centres. The original theca was apparently subglobose.

Height, as preserved, 36 mm.; width 40 mm.

Occurrence.—Bomide formation. East edge of McLish Ranch, Johnson Co., Sec. 36, T. 1S, R. 7E, Okla.

Crinoidea

Genus HYBOCRINUS Billings

This genus has been thoroughly discussed by many authors and two of its species, *H. tumidus* and *H. conicus* Billings, are well known. *H. punctatus* (Miller and Gurley), described as having punctate plates and only four arms, is not closely comparable with the present species. The fourth described species, *H. pristinus* Billings, is less well-known, and a specimen from the Chazy limestone near Montreal is figured for comparison (Plate 2, figs. 8-10).

Hybocrinus nitidus, new species

Plate 2, Figs. 1-4

Description.—Dorsal cup of medium size, subglobular in shape. Basals large, kite-shaped; the two which support the left-posterior radial are slightly larger than the other three, causing a slight humping. Radials large and pentagonal, except the right, which is hexagonal. Radianal large, pentagonal, in line with the radials. Anal and right-posterior radial not well preserved. Brachial facets prominent, the anterior especially projecting. Orals rather large, concave, meeting in front of the radials to form a shallow V-shaped through running towards the mouth. Surface of the plates with low scattered tubercles.

Height of holotype (number 5003), 11 mm.; width from left to right, 12 mm.; from front to back, 10 mm. Height of basals: left and left-posterior, 8 mm.; right to right-anterior, about 6.5 mm. A paratype (number 5004, plate 2, figure 4) has the right-posterior radial and the anal preserved and projecting well above the rest of the ventral margin of the cup.

Occurrence.—Bromide formation, about 170 feet above the base. West branch of Sycamore creek, Sec. 27, T. 3S, R. 4E, Okla. An unfigured paratype is numbered 5005.

Remarks.—This species is much smaller and more spherical than *H. conicus* and is smaller than *H. tumidus,* with more nearly equal basals and therefore a more regularly rounded cup. It lacks the strong asymmetry of *H. pristinus.*

Hybocrinus pyxidatus, new species

Plate 2, Figs. 5-7

Description.—Dorsal cup fairly large, subquadrate. Basals large, unequal. Radials large; the right- and left-posterior larger than the anterior and left, which in turn are larger than the right-posterior, which is small and quadratic. Radianal large; anal small, quadrate, with moderate projection. Orals rather large, triangular; their areas of contact are covered with a series of small (0.3 mm.) irregular plates, which also cover the central part of the oral surface. No anal pyramid is seen, but this area is obscured. Surface almost smooth, with very fine granules.

Height, 21 mm.; width, front to back, 16.5 mm. Height of basals: anterior/left, 9 mm.; left/left-posterior, 11; left-posterior/right-posterior, 11.5; right-posterior/right, 12; right/anterior, 9.5. Height and width of radials: right, 12 x 12 mm.; anterior, 9 x 10; left, 9.5 x 11; left-posterior, 10 x 13; right-posterior, 6.5 x 7; of the radianal, 12 x 11; of the anal, 4.5 x 6 approximately. Orals, 3.8 mm. high and 3 wide.

Occurence.—Type (number 5010), 170 feet above the base of the Bromide formation. West branch of Sycamore creek, Sec. 27, T. 3S, R. 4E, Okla. Also about 80 feet above the base of the formation on the East side of U. S. highway 77, Sec. 25, T. 2S, R. 1E, Okla.

Remarks.—This species is more tumid than *H. conicus,* is smaller and has

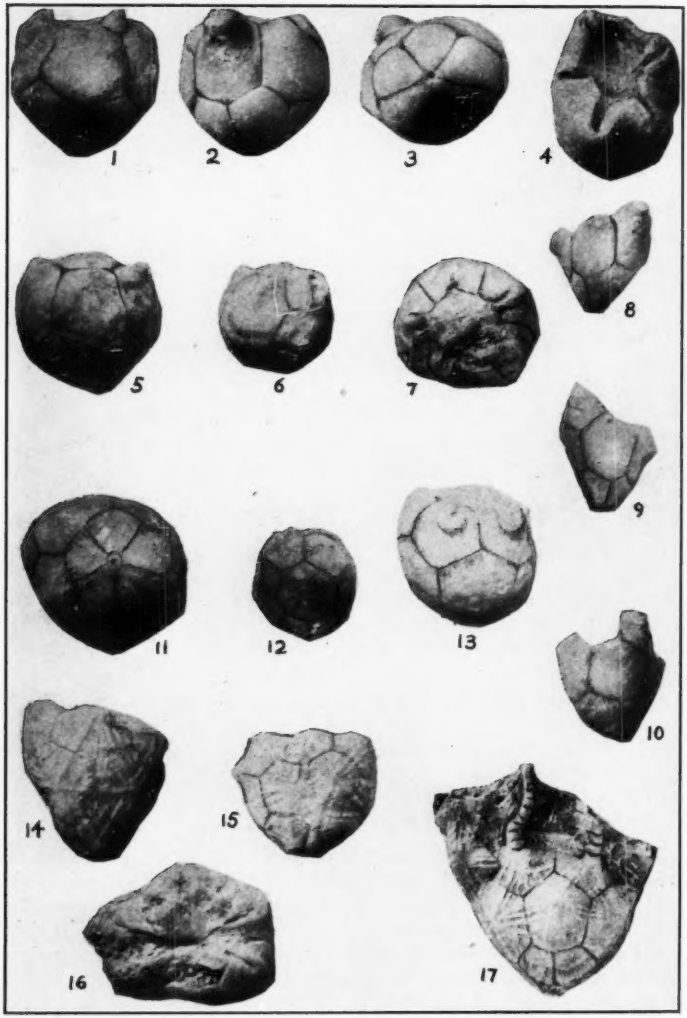

PLATE 2.—Figs. 1-4. *Hybocrinus nitidus*, new species. 1-3, posterior, anterior and basal views of holotype. 4, tegminal view of a paratype. All ×2. Figs. 5-7. *Hybocrinus pyxidatus*, new species. Right side, left-posterior side and tegmen of holotype. 5 and 7, ×1.5; 6 ×1. Figs. 8-10. *Hybocrinus pristinus* Billings. Left, right and posterior views of a topotype, from the upper Chazy near Montreal. All ×2. Figs. 11-13. *Palaeocrinus hudsoni*, new species. Basal, right-posterior and right views of type. 11 and 13, ×2; 12, ×1.5. Figs. 14-16. *Carabocrinus treadwelli*, new species. Right, posterior and tegminal views of type. 14 ×1.5; 15 and 16, ×1. Fig. 17. *Carabocrinus huronensis* Foerste. Anterior view of a specimen from the lower Trenton at Kirkfield, Ontario, a little less than natural size.

more unequal basals. It is much larger and more symmetrical than *H. pristinus*, and is more tumid, more globular and larger than *H. tumidus*.

Genus PALAEOCRINUS Billings

Palaeocrinus hudsoni, new species

Plate 2, Figs. 11-13

Description.—Dorsal cup of medium size, subglobose and in its present condition somewhat asymmetrical. Infrabasals equal, widely flaring, rather high, with the height about equal to the width. Basals large, hexagonal, equal. Radials equal the basals in size and are incurved ventrally, but not at a sharp angle. Radianal apparently quadrate; anal not preserved.

Basals with about five covered canals leading to each of the two adjacent infrabasals; about six to each adjacent basal, and about five to each of two radials, or to a radial and a radianal; radials with about nine canals leading to each adjacent radial.

Height, 14 mm.; width, 19 x 14.5 mm., with the greatest width from front to back. Infrabasals about 5 mm. high, basals about 8 mm., left-posterior radial, 7 mm.

Occurrence.—Type (number 5006), about 170 feet above the base of the Bromide formation. West branch of Sycamore creek, Sec. 27, T. 3E, R. 4E, Okla. Specimens referred to the species also were found in the Bromide west on Nebo, about 10 miles south of Sulphur, Sec. 22, T. 2S, R. 3E, Okla.

Remarks.—Palaeocrinus hudsoni differs from all described species of the genus in the shape of the cup, since the flaring infrabasals give it a globular rather than a conical shape. It also lacks the strong ridges of *P. angulatus* Billings .The specific name honors that thorough student of Ordovician echinoderms, the late George Henry Hudson.

Genus CARABOCRINUS Billings

Carabocrinus treadwelli, new species

Plate 2, Figs. 14-16

Description.—Dorsal cup of medium size, wedge-shaped, slightly compdessed. Infrabasals of medium size, unequal, with one or two V-shaped ridges. Basals rather large, with five to six strong ridges leading from the centre to the edges, as well as a few intermediate ridges. Radials equals in size to the basals or a little smaller and bent sharply inward at the top of the cup; they are ornamented with one or two inverted V-shaped ridges and a pair of horizontal ones running around the cup. Infraradianal quadrangular, rather small. Supraradianal obscurely pentagonal, with strong X-shaped ridges and many weaker ones. Anal pentagonal, a little smaller than the radials, ridged like them. Orals large, triangular, with rounded sides.

At the junction of each oral and the two adjacent radials there is a series of folds, about 8 on the oral and about 15 on each radial, all directed toward

the point of juncture. In shape and structure they resemble the "pore" areas in *Porocrinus* Billings, but are much smaller. Miss Alice E. Wilson, who has examined Billings' specimens of *Carabocrinus radiatus* (the genotype), informs me that this structure is present in it, although hitherto undescribed.

Brachial facets rather large, with a narrow groove extending through the radial and then between the orals. There are a few scattered plates on the ventral surface but their original position cannot be determined. Periproctal area unknown.

Height, 20 mm.; width, front to back, 16 mm.; left to right, 22 mm.

Occurrence.—Bromide formation. Southwest of Nebo store, Sec. 2, T. 2S, R. 7E, Okla. The type, number 5007, was collected by T. K. Treadwell, Jr.

Remarks.—The wedge-shaped base of *C. treadwelli* distinguishes sharply from such species as *C. radiatus* Billings and *C. esthonus* Jaekel, which are broadly rounded below. The cup in *C. vancortlandi* Billings and *C. ovalis* Miller and Gurley narrows toward the top, giving an oval shape which is quite lacking in the present species. *C. slocomi* Foerste and its variety *costatus* are distinguished by their less numerous ridges, and the smaller number of grooves on the radials. *C. geometricus* Hudson is much smaller and its infrabasals are proportionately smaller. *C. dicyclinus* and *C. magnificus* Sardeson are much larger, broad bottomed species. *C. huronensis* Foerste has not been illustrated, and a specimen from the lower Trenton at Kirkfield, Ontario, is figured here for comparison (plate 2, figure 17). It is larger than *C. treadwelli,* and its basals are much larger in proportion to the whole cup.

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A New Deepkill Eurypterid

Rousseau H. Flower

While engaged in a restudy of the stratigraphic distribution of graptolites in the type section of the Deepkill shale, Rensselaer County, N. Y., the writer discovered the small eurypterid described below. The form is of interest in that it is the first occurence in the Canadian strata of a eurypterid having the aspect of the Silurian genus *Eusarcus*.

The generic position of this species is dubious. The prosoma is typical of *Eusarcus*, which is typically developed in the Silurian. Other members of the genus have been described from rocks of Trenton and Cincinnatian age. However, the present species occurs in beds which are certainly not younger than the Canadian, and are probably Middle Canadian, if not older, for graptolites homotaxial to those of the overlying graptolite beds 3-5 of the Deepkill Section occur in the Powell limestone of the Ozark region. With few exceptions, the body and appendages of Ordovician eurypterids are poorly known. A very large pterygotid, soon to be described by Dr. K. E. Caster from the Richmond of Manchester, Ohio, has a prosoma typical of *Pterygotus*, yet the remainder of the animal is so different in body pattern that a new genus must be erected for it. This indicates further the need of caution in generic determination of Ordovician Eurypterida on the basis of prosomal characters alone.

Three eurypterids have been previously described from the Deepkill. One of these, *Pterygotus deepkillensis* Ruedemann (1934) is from approximately the same horizon as the present species; that is, from the zone characterized by horizontal *Didymograptus* species, and represented in the Deepkill Section by beds 1 and 2. The other two, *Dolichopterus antiquus* Ruedemann and *Pterygotus* (?) *priscus* Ruedemann (1942) are from the beds exposed at the Ash Hill quarry at Mt. Merino, south of Hudson, N. Y. Ruedemann (1904, p. 499), on the basis of their fauna regarded the fossiliferous beds at this exposure as intermediate in position between beds 5 and 6 of the Deepkill Section.

Some of the eurypterids found in graptolite shale occurred under such conditions as to suggest that they might have been only cast skins washed into the black shale facies. (Reudemann 1934, p. 40-41). The occurrence of eurypterids in a shale layer directly on top of Normanskill grits, with some specimens on the surface of the grit layer itself, suggested deposition of the materials during transition from strong to weaker currents.

The specimen described in this paper was found under very different conditions. The type is from a layer of soft and very fine-grained black shale three-fourths of an inch in thickness. The material was evidently fine-grained mud and contains remarkably large and perfect specimens of *Tetragraptus fruiticosus, Goniograptus thureaui* var. *postremus*, and several species of *Didymograptus*. The underlying shales assume a slightly coarser texture for

the next 6 inches, but continue to carry a rich fauna of graptolites. Near the base of the 6-inch layer the graptolites are broken and arranged in a parallel direction by currents. The beds overlying the one bearing the eurypterid consist of barren, fine, gray-green muds with no evidence of life other than the burrows of worms. Evidently both the fine mud and the exceedingly perfect and unbroken graptolites could have settled only under unusually quiet conditions. The occurrence of our eurypterid in such an environment suggests, though it cannot be said to prove, that it was a part of the epiplanktonic assemblage. Ruedemann (1934A, 1942), on the basis of additional eurypterids from graptolite shales, has concluded that they evidently formed a part of the fauna living among a Paleozoic sargasso association.

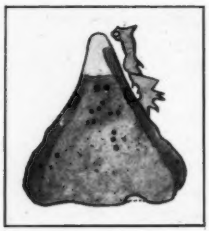

Fig. 1. *Eusarcus* (?) *ruedemanni* sp. nov. Holotype, a prosoma. The snout-like anterior projection, represented in a lighter color, is shown only on the reverse, being lost by flaking on the slab retaining most of the head. ×2.

Eusarcus (?) ruedemanni, n. spec.

Description.—The holotype consists only of a prosoma 6.5 mm. in length, to the side of which is attached one poorly preserved appendage. Prosoma subtriangular, posterior of head undulate, posterior lateral margins broadly rounded. The sides are sinuous, convex posteriorly, becoming concave in front of the eyes, ending in a prolonged narrowly rounded rostrum. The eyes are marginal, situated about one-third of the distance from the anterior to the posterior margin. Two ocelli occur close together, just in front of a line connecting the anterior margin of the two compound eyes. The surface bears traces of small rounded scales. Traces of the doublure are shown laterally. It is narrow and is essentially parallel to the sides of the prosoma. The one appendage fails to show its segments or structure clearly, and is evidently badly macerated. Its present condition suggests original spinosity.

Discussion.—Both surfaces of the bedding plane containing this specimen were available. Owing to flaking of the shale, the present illustration is a combination of camera lucida drawings of both halves of the specimen. The greater part of the head was represented on the one surface, but recourse was had to the other to complete the outline of the anterior margin. This portion is indicated in the figure by a somewhat lighter color than was used for the remainder.

The margins of the head are rather irregular. The integument shows only as a faint silvery patch on the graptolite shales and differs materially from the graptolite remains, which are much better defined. These facts suggest that the prosoma is one lost by moulting. The small size of the individual suggests that it may have been immature, but no adequate criteria are available for decision as to its age.

The shape of the prosoma, as well as the anterior position of the eyes and ocelli, show that this species is more closely allied to *Eusarcus* than to species thus far placed in any other genus. *E. linguatus* Clarke and Ruedemann of the Normanskill shale differs from this species in lack of the marked prolongation of the front of the head; the lateral margins of the head also are convex throughout, and the ocelli are posterior to the compound eyes. *E. vaningeni* Clarke and Ruedemann, of the Clinton group in New York, has a similarly produced rostrum, but the eyes are more centrally located, the ocelli are posterior, the lateral margins of the head are more sinuate, and become convex in front of the eyes. Further, this Silurian species is much larger than the Deepkill form. *E. triangulatus* Clarke and Ruedemann (see Ruedeman 1934) of the Snake Hill beds, has a broader and blunter head with larger and more prominent compound eyes. *E. breviceps* Ruedemann (1926), of the Utica shale, is not strikingly similar to the present species, having the head broadly rounded with only a faint anterior prolongation.

Holotype.—New York State Museum.

Occurrence.—Upper part of Bed 1 of the Deepkill shale, at the Deep Kill, Rensselaer County, N. Y.

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The Occurrence of Petrodus in Oklahoma

J. Willis Stovall

Faculty and students from the school of geology at the University of Oklahoma have been collecting fossil shark teeth for a number of years from various Pennsylvanian formations in Oklahoma: the Wetumka, T.3N., R.7E., Sec. 18; the Wewoka, T.5N., R.8E., Sec. 33; the Francis from the brick pit about one mile south of Ada, Oklahoma. George D. Morgan [1] (1924) lists and illustrates *Petrodus occidentalis* Newberry and Worthen from the lower Boggy formation of Oklahoma. G. H. Girty [2] (1915) however, did not mention the occurrence of any shark remains in the Wewoka formation.

This discussion is based on a large number of specimens, none of which show more variation than would be expected in the individuals of one species. They correspond very closely to the original drawings and compare favorably with the descriptions of the type *P. occidentalis*. The description given by Newberry and Worthen [3] (1866) follows:

> Base subcircular or elliptical in outline, flat or slightly concave below, thin, terminating in an abruptly sharpened, finely crenulated edge; broader than the crown; crown broadly conical, acute or rounded at the summit, with a subcircular or elliptical section, constricted at the base, marked with a variable number of strong, divergent ridges, many of which are forked below; ridges generally smooth but sometimes more or less rugose.

Some specimens agree perfectly with this description, however, some show the rugose, divergent ridges extending only a small portion of the total distance up the sides of the tooth. In all specimens the base is elliptical or rounded in cross section. In small specimens the base is generally convex but in the larger ones it is concave. As Newberry and Worthen pointed out, there is a varying number of divergent ridges, although if each one of the lower forks is counted, thirteen appears to be the average number.

The following table of measurements, given in millimeters, show the variations in size and form:

Specimen	Height	Min. Diam.	Max. Diam.
1	10.5	12.9	14.8
2	8.9	10.4	11.2
3	11.9	11.5	12.8
4	8.5	9.8	10.7
5	9.0	9.9	11.0
6	6.9	8.8	11.0
7	4.7	6.6	6.8

1 Morgan, George D. Geology of the Stonewall Quadrangle, Oklahoma. Oklahoma Bureau of Geol. Bull. No. **2**, pp. 83. 1924.

2 Girty, G. H. Fauna of the Wewoka Formation of Oklahoma. U. S. G. S. Bull. **544**, 1915.

3 Newberry, J. S. and A. H. Worthen. Descriptions of New Species of Vertebrates, Mainly from the Sub-Carboniferous Limestone and Coal Measures of Illinois. Geological Survey of Illinois. Vol. 2, Section 1, pp. 70. 1866.

Because of their close agreement with the type, these specimens have been identified as *Petrodus occidentalis*, the first specimen of which came from the "Coal Measures" at Belleville, Illinois. Since Newberry and Worthen first described the species it has been found to occur in many localities. Further search may show it to be present in the shales between the Boggy and Francis in the Oklahoma area.

The following section from the Pennsylvanian of Oklahoma shows the vertical range of the species. It is based on 66 specimens:

Francis	*Petrodus* present	Wetumka	*Petrodus* present
Seminole	Not found		
	Disconformity	Calvin	Not found
Holdenville	Not found	Senora	Not found
		Thurman	Not found
Wewoka	*Petrodus* present		Disconformity
		Boggy	*Petrodus* present

The above section shows an interval of about 3,000 feet between the highest and lowest occurrence of *Petrodus* in this area. A rather long range is thus indicated for the genus. It is significant that two rather marked disconformities separate the top and bottom *Petrodus* horizons.

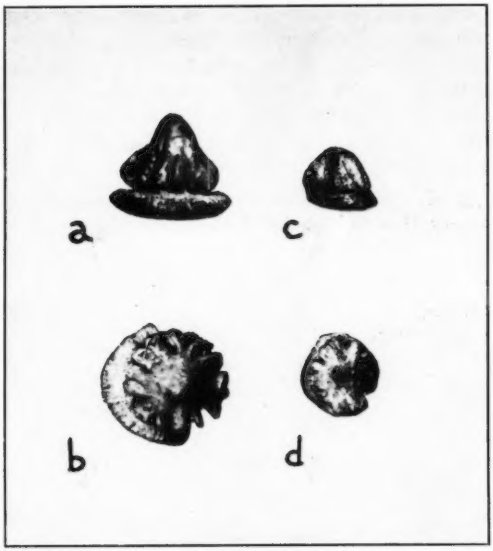

Fig. 1. Two specimens of *Petrodus occidentalis;* (a) lateral and (b) dorsal view of the same specimen; (c) lateral and (d) dorsal view of the same specimen. All figures natural size.

The question has been raised as to whether these are true buccal teeth or dermal ossicles. Newberry and Worthen considered the matter and Agassiz was of the opinion that they were not true teeth. Some support is lent to this view by the fact that the bases of the teeth show no evidence of having fitted together as do the teeth in *Orodus, Ptychodus,* and *Acrodus* and that they also have some resemblance to the cutaneous tubercles of some of the living fish, particularly the sharks and rays. I have before me, however, two *Petrodus* denticles that are still closely joined together, apparently in the same condition as found in the living animal. These denticles came from Sec. 18, T.3N., R.7E., from the Wetumka Formation. This condition might prevail if the specimens in question were cutaneous tubercles. Some years ago, Mr. Dan Jones made thin sections of one of these teeth and found no differentation of "pulp, enamel, or cement." However, the writer has recently prepared thin sections of several of these teeth and they show definite zones of differentiated tissue. There is an outer layer of enamel (?) and an inner mass of osteo-dentine. These same structures are also found in the dermal plates and spines of some of the sharks. Tome [4] (1923) says "There are many dermal spines to be met with in the sharks and on the back or tail of rays, which seen alone could not possibly be distinguished from teeth, ..." This is to be expected since the teeth and spines and scales of fish are identical in their development and histological structure. The specimens under consideration show definite signs of wear on the peak as if they had been given considerable use in the attrition of resistant matter, such as mollusks and crustaceans. They appear to show more wear than would be caused on dermal denticles by a fish accustomed to wallow on the bottom. The writer inclines to the view that these are true teeth.

4 Tomes, Sir Charles S., Kt. A Manual of Dental Anatomy. Eighth Edition. The Macmillan Company, New York. pp. 260. 1923.

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The Genus Isolepis R. Br.

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Use of the genus *Isolepis* (Cyperaceae) was confined to the Nineteenth Century. Robert Brown in 1810 (Prod. Fl. Nov. Holl.) separated it from other genera in the tribe Scirpeae on the artificial basis of perianth absent, to quote "Habitus *Scirpi*, a quo differt defectu setarum hypogynarum." This genus was readily accepted along with other natural genera of Brown, e.g. *Eleocharis*, by Roemer and Schultes, Nees, Kunth and others. Greatest recognition for the genus came with Steudel who in 1855 in his "Synopsis Plantarum Graminearum"—(Pars II. Cyperaceae) listed 200 names, 70 of which were his own. Boeckeler in his "Die Cyperaceen Des Königlichen Herbariums zu Berlin" in 1869-70 finally recognized that the genus was artificial and included all the *Isolepis* names known to him in other genera, mostly *Scirpus*. A majority of the subsequent workers took the lead of Boeckeler, although a few writers, e.g. Philippi (1880-1896), continued to describe new names in *Isolepis*. At the turn of the Century the genus was wholly discarded but by that time 470 synonyms had been made.

The present compilation was undertaken for the following reasons: (a) this list presents the genus in more usable form, more up to date, and more complete than it can be found elsewhere. (b) it makes more intelligible much Nineteenth Century botanical literature—especially to students not specializing in the Cyperaceae. (c) by focusing attention on these names which are usually neglected but often valid in combination it will contribute to the stability of the nomenclature in the natural genera of the Cyperaceae.

Although by far the largest number of the 470 names in *Isolepis* are synonyms of species or varieties of *Scirpus*, altogether they represent 18 genera accepted today in the Cyperaceae:

Ascolepis (1)	*Eleocharis* (22)	*Pleurostachys* (1)
Bulbostylis (81)	*Ficinia* (30)	*Pycreus* (1)
Carex (2)	*Fimbristylis* (62)	*Rhynchospora* (4)
Cladium (1)	*Fuirena* (2)	*Schoenus* (2)
Cyperus (3)	*Hemicarpha* (6)	*Scirpus* (241)
Desmoschoenus (1)	*Mariscus* (1)	*nomina dubia* (7)
Dichostylis (2)		

Leading authors in number of names include:

Steud. (70)	A. Dietr. (23)	R. Br. (12)
Nees (51)	Boeck. (15)	Hochst. (12)
Kunth (42)	Phil. (15)	Presl (9)
R. & S. (30)	H. B. K. (13)	Link (6)
Schrad. (29)	Schult. (13)	Torr. (6)

Isolepis

abyssinica Hochst. in Dur. & Schinz. Consp. Flor. Afr. **5**:605. 1895—*Fimbristylis exilis* (Willd.) R. & S.

acaulis F. Muell. in Hook. f. Handb. N. Zeal. Fl. 302. in obs. 1867; Benth. Fl. Austr. **7**:324. 1878.—*Scirpus humillimus* Benth. & Muell.
acaulis Phil. ex Boeck. in Linnaea **36**:440. 1870.—*Scirpus deserticola* Phil.
acicularis A. Rich. Fl. Nouv. Zel. 103. 1832.—*Scirpus gracilis* R. Br.
acicularis Schlecht. Fl. Berol. **1**:36. 1823.—*Eleocharis acicularis* (L.) R. & S.
acrostachya Schrad. Anal. Fl. Cap. aden. 23. 1832.—*Ficinia acrostachya* (Steud.) C. B. Clarke.
acugnana Schult. Syst. Veg. **2**: mant. 532. 1824.—*Scirpus thouarsianus* Schult.
acuminata A. Dietr. Sp. Pl. **2**: 103. 1833; **1**:193. 1840.—*Ficinia acuminata* (Steud.) Nees.
acuminata Nees, Linnaea **7**:501. 1832; **10**:162. 1836.—*Ficinia acuminata* (Steud.) Nees.
albescens Desv. in C. Gay, Hist. fis. y polit. Chil. **6**:188. t. 70. fig. 2. 1853.—*Scirpus inundatus* Poir.
albescens Miq. Linnaea **19**:226. 1847.—*Bulbostylis albescens* (Miq.) Beetle.
albicans A. Dietr. Sp. Pl. **2**:103. 1833.—*Ficinia albicans* Nees.
allochroa Steud. Syn. Pl. Glum. Pars. II. Cyp. 79. 1855.—*Eleocharis atropurpurea* (Retz.) Kunth.
alpina Hook. f. Fl. Tasm. 2: 86. t. 143. 1867.—*Scirpus gunnii* Boeck.
ambigua Nees, Linnaea **9**:291. 1834.—*Bulbostylis junciformis* (HBK) Lindm.
ambigua Zollinger, Syst. Verz. Ind. Arch. **2**:62. 1854.—*Scirpus uninodis* (Delile) Beetle.
anceps A. Dietr. (Roxb. Fl. Ind. 1: 234. 1832) Sp. Pl. **2**:125. 1833; **1**:196. 1840.—*Fimbristylis complanata* (Retz.) Link.
andina Phil. Anal. Mus. Nac. Chile 79. 1891.—*Eleocharis pauciflora* (Lightf.) Link.
angachillensis Steud. in Boeck. Flora **42**:448. 1839.—*Scirpus inundatus* Poir.
angularis Schrad. in R. & S. Syst. Veg. **2**: mant. 69. 1824.—*Fimbristulis quinquangularis* Kunth.
antarctica Nees, Linnaea **7**:505. 1832.—*Scirpus diabolicus* Steud.
antarctica R. & S. Syst. Veg. **2**:112. 1817—*Scirpus antarcticus* L.
aphylla Boeck. Flora **41**:417. 1858.—*Eleocharis albida* Torr.
aquatilis Kunth, Enum. Pl. **2**:215. 1837.—*Scirpus tenuissimus* (Nees) Boeck.
arcuata Eckl. ex Kunth (Enum. Pl. **2**:254. 1837) in Dur. & Schinz. Consp. Flor. Afr. **5**:640. 1895.—*Ficinia lateralis* (Vahl) Kunth.
arenaria Nees, Linnaea **9**:291. 1834.—*Bulbostylis arenaria* (Nees) Lindm.
ariculata Presl, Delic. Prag. 144. 1822.—*Scirpus americanus* Pers. var. *triangularis* (Pers.) Beetle.
armerioides Miq. Fl. Ind. Bot. **3**:310. 1859.—*Fimbristylis armerioides* (Miq.) Beetle.
armerioides Miq. var. *minor* Miq. Fl. Ind. Bot. **3**:310-311. 1859.—*Fimbristylis armerioides* (Miq.) Beetle.
articulata Nees, in Wight. Contrib. 108. 1834.—*Scirpus articulatus* L.
ascolepis A. Rich, Tent. Fl. Abyss. **2**:501. 1847-51.—*Ascolepis eriocauloides* (Nees) Steud.
asperula HBK, Nov. Gen. et Sp. **1**:221. 1816.—*Bulbostylis tenuifolia* Nees.
atacamensis Phil. Fl. Atacamensis 53. 1860.—*Scirpus atacamensis* (Phil.) Boeckl.
atropurpurea Nees, Linnaea **7**:495. 1832.—*Scirpus africanus* Beetle.
atropurpurea R. & S. Syst. Veg. **2**:106. 1817.—*Eleocharis atropurpurea* (Retz) Kunth.
aucklandica Hook. f. Handb. New Zeal. Fl. 302. 1867.—*Scirpus aucklandicus* (Hook. f.) Boeckl.
australis Bluff, Nees & Schauer, Compl. Fl. Germ. I. I. 82. 1836.—*Scirpus holoschoenus* L.
australis R. & S. ex G. Don, Lond. Hort. Brit. 21. 1831-38.—*Scirpus holoschoenus* L.
autumnalis J. & C. Presl, Rel. Haenk. **1**:189. 1828.—*Fimbristylis autumnalis* (L.) R. & S.
barbata R. Br. Prod. Fl. N. Holl. I. 222. 1810.—*Bulbostylis barbata* (Rottb.) C. B. Clarke.
basilaris Hook. f. Handb. N. Zel. Fl. 302. 1867.—*Scirpus basilaris* (Hook. f.) C. B. Clarke.
bellula Steud. Syn. Pl. Glum. Pars. II. Cyp. 318. 1855.—*Scirpus isolepis* (Nees) Boeck.

bergiana Drege, Zwei Pfl. Docum. 120. 1844.—*Scirpus dregeanus* C. B. Clarke.
bergiana Schult. Syst. Pl. **2**: Mant. 532. 1824.—*Scirpus antarcticus* L.
bergiana Spreng. in Nees, Linnaea **9**:290. 1834. *Nomen nudum et dubium.*
berlandieri Steud. Syn. Pl. Glum. Pars. II. Cyp. 103. 1855. *Bulbostylis junciformis* (H.B.K.) Lindman.
beyrichii Schrad. ex Nees in Mart. Fl. Bras. II. I. 88. 1840.—*Bulbostylis arenaria* (Nees) Lindman.
biceps Eckl. ex Kunth in Dur. & Schinz, Consp. Flor. Afr. **5**:637. 1895.—*Ficinia bulbosa* (L.) Nees.
bicolor Carmich. Trans. Linn. Soc. **12**:503. 1819.—*Scirpus thouarsianus* Schult.
bicolor Nees, Linnaea **9**: 291. 1834.—*Scirpus venustulus* (Kunth) Boeck.
bispicata Schult. in R. & S. Syst. Veg. **2**: mant. 61. 1824.—*Fimbristylis schoenoides* Vahl.
bivalvis Steud. Syn. Pl. Glum. Pars. II. Cyp. 101. 1855.—*Fimbristylis longiculmis* Steud.
boeckeleri Oliv. Trans. Linn. Soc. **29**:167. 1875.—*Cyperus dubius* Rottb. var. *coloratus* (Vahl) Kukenth.
brachyphylla J. & C. Presl, Rel. Haenk. **1**:187. 1828.—*Scirpus cernuus* Vahl.
brachyphylla Schult. in R. & S. Syst. Veg. **2**: mant. 62. 1824.—*Bulbostylis capillaris* (L.) C. B. Clarke.
breviculmis Kunth, Enum. Pl. **2**:207. 1837.—*Bulbostylis breviculmis* (Kunth) C. B. Clarke.
brevifolia Presl, Rel. Haenk. **1**:351. 1828.—*Scirpus cernuus* Vahl.
brevis Brongn. in Duperry Voy. Coquille Pars **2**:180. 1829.—*Scirpus cernuus* Vahl.
bridgesii Palla, in Engl. Bot. Jahrb. **10**:300. 1888.—*Scirpus inundatus* Poir.
bufonia H.B.K. Nov. Gen. et Sp. **1**:22. 1816.—*Bulbostylis capillaris* (L.) C. B. Clarke.
bulbosa Nees, Linnaea **7**:507. 1832.—*Ficinia bulbosa* (L.) Nees.
caespitosa Liebm. Vidensk. Skr. V. **2**:237. 1851.—*Hemicarpha micrantha* (Vahl) Pax.
capillaris Don, Prod. Fl. Nepal. 39. 1825.—*Bulbostylis wallichiana* (Schult.) Beetle.
capillaris Ehrenb. in Boeck. Linnaea **36**:500-502. 1870.—*Scirpus cernuus* Vahl.
capillaris R. & S. Syst. Veg. **2**:118. 1817.—*Bulbostylis capillaris* (L.) C. B. Clarke.
capillaris R. & S. var. *europea* Kunth, Enum. Pl. **2**:212. 1837.—*Bulbostylis capillaris* (L.) C. B. Clarke.
carinata H. & A. in Torr. Ann. Lyc. **3**:349. 1836.—*Scirpus koilolepis* (Steud.) Gleason
carmichaelii A. Dietr. Sp. Pl. **2**:107. 1833; **1**:194, 1840.—*Scirpus sulcatus* Thouars.
cartilaginea R. Br. Prod. Fl. N. Holl. 222. 1810.—*Scirpus antarcticus* L.
cernua R. & S. Syst. Veg. **1**:106. 1817.—*Scirpus cernuus* Vahl.
chaetodes Link in L. de Buch, Beschr. Canar. Ins. 138. 1819.—*Scirpus cernuus* Vahl.
chlorostachya Nees, Linnaea **9**:291. 1834.—*Scirpus cernuus* Vahl.
chlorotica Phil. ms. acc. to Clarke, Cyp. Chil. Bot. Jahrb. von Engl. **30**:27. 1901.—*Scirpus cernuus* Vahl.
chrysocarpa Nees, Linnaea **7**:499. 1832.—*Scirpus antarcticus* L.
ciliata Presl, Rel. Haenk. **1**:188. 1828.—*Bulbostylis capillaris* (L.) C. B. Clarke
ciliatifolia Torr. Ann. Lyc. N. York **3**:350. 1836.—*Bulbostylis capillaris* (L.) C. B. Clarke.
ciliifolia Steud. Syn. Pl. Glum. Pars II. Cyp. 99. 1855.—*Bulbostylis conifera* (Kunth) Beetle.
cinnamometorum R. & S. Syst. Veg. **2**:119. 1817.—*Fimbristylis cyperoides* R. Br.
circinata Kunth, Enum. Pl. **2**:214. 1837.—*Bulbostylis circinata* (Kunth) C. B. Clarke.
clathrata Rchb. Icon. Flor. Germ. et Helv. **8**:39. 1846.—*Scirpus cernuus* Vahl.
coarctata A. Dietr. Sp. Pl. **2**:117. 1833.—*Bulbostylis capillaris* (L.) C. B. Clarke.
coarctata Torr. Ann. Lyc. N. York **3**:102. 1836. *Bulbostylis capillaris* (L.) C. B. Clarke.
cochleata Steud. Syn. Pl. Glum. Pars. II. Cyp. 100. 1855.—*Fimbristylis setacea* Benth.
collina Kunth, Enum. Pl. **2**:208. 1837.—*Bulbostylis collina* (Kunth) C. B. Clarke.
commutata Nees, Linnaea **10**:81. 1835-36.—*Ficinia gracilis* (Poir.) Schrad.
complanata R. & S. Syst. Veg. **2**:119. 1817.—*Fimbristylis complanata* (Retz) Link.
compressa Nees, Linnaea **10**:157. 1836.—*Scirpus neesii* Boeck.
conceptiones Steud. Syn. Pl. Glum. Pars. II. Cyp. 94. 1955.—*Scirpus inundatus* Poir.

congesta Schrad. ex Schult. in R. & S. Syst. Veg. **2**: mant. 70. 1824.—*Bulbostylis consanguinea* Nees.
congrua Nees in Lehm. Pl. Preiss. **2**:75. 1844-47.—*Scirpus congruus* (Nees) S. T. Blake.
conifera Kunth, Enum. Pl. **2**:206. 1837.—*Bulbostylis conifera* (Kunth) Beetle.
conostachya Boeck. Linnaea **36**:756. 1870.—*Bulbostylis conostachya* (Boeck.) Beetle.
consanguinea Kunth, Enum. Pl. **2**:211. 1837.—*Bulbostylis consanguinea* Nees.
consocialis Steud. Syn. Pl. Glum. Pars. II. Cyp. 318. 1855.—*Fimbristylis exilis* (Willr.) R. & S.
conspersa Nees, in Endl. Prod. Fl. Norf. 23.—*Scirpus inundatus* Poir.
contexta Nees in Boeck. Linnaea **36**:746. 1870.—*Bulbostylis collina* (Kunth) C. B. Clarke.
controversa Steud. Nom. Bot. ed. II. 826. 1840; Syn Pl. Glum. Pars. II. Cyp. 92. 1855.—*Scirpus cernuus* Vahl.
coronaria R. & S. Syst. Veg. **2**:113. 1817.—*Cyperus coronarius* (Vahl) Kunth.
corymbosa J. & C. Presl, Reliq. Haenk. **1**:188. 1828.—*Rhynchospora exilis* R. & S.
corymbosa Roth in R. & S. Syst. Veg. **2**: 110. 1817.—*Scirpus inclinatus* Aschers. & Schweinf. ex Boiss.
corymbosa var. *microstachys* Bcklr. Linnaea **36**:706. 1870.—*Scirpus brachyceras* Hochst.
costata A. Rich. Tent. Fl. Abyss. **2**:499. 1851.—*Scirpus costatus (A. Rich.)* Boeck. or—*Ficinia costata* (Hochst ex A. Rich) Pfeiff. acc. Pfeiff. 22. 1920.
crassiuscula Hook. f. Fl. Tasm. **2**:86. t.[t]143. 1867.—*Scirpus lenticularis* Poir.
crinita Schrad. ex Nees, in Mart. Fl. Bras. **2**:I. 82. 1840.—*Bulbostylis circinata* (Kunth) C. B. Clarke.
cumingii Steud. Syn. Pl. Glum. Pars. II. Cyp. 101. 1855.—*Scirpus mindorensis* Beetle.
curvata Kunth in Zoll. Syst. Verz. Ind. Arch. **2**:62. 1854.—*Scirpus fluitans* L.
curvifolia Schrad. in R. & S. Syst. Veg. **2**: mant. 70. 1824.—*Fimbristylis diphylla* (Retz.) Vahl.
curvula Kunth, Enum. Pl. **2**:189. 1837.—*Scirpus fluitans* L.
cuspidata A. Dietr. Sp. Pl. **2**:120. 1833; **1**:195. 1840.—*Fuirena wallichiana* Kunth.
cyperoides R. Br. Prod. Fl. Nov. Holl. 222. 1810.—*Scirpus brunonianus* S. T. Blake.
decipiens Nees, Linnaea **10**:157. 1835-36.—*Scirpus paludicolus* Kunth.
densa (Wall.) R. & S. Syst. Veg. **2**: mant. 71. 1824; Wight, Contrib. Bot. Ind. 109. 1834.—*Bulbostylis densa* (Wall.) Beetle.
depauperata Link, Jahrb. i. III. 79. 1820.—*Fimbristylis diphylla* (Retz) Vahl.
deserticola Phil. Fl. Atacamensis 53. *Scirpus deserticola* Phil.
diabolicus Schrad. Anal. Fl. Cap. 21. 1832.—*Scirpus diabolicus* (Schrad.) Steud.
dichotoma HBK, Nov. Gen. et Sp. **1**:223. 1816.—*Fimbristylis diphylla* (Retz) Vahl.
dichroa Steud. Syn. Pl. Glum. Pars. II, Cyp. 79. 1855.—*Eleocharis atropurpurea* (Retz) Kunth.
digitata Nees ex Schrad. Anal. Cap. Cyp. 20. 1832.—*Scirpus digitatus* (Nees) (Boeck.)
dioeca Kunth, Enum. Pl. **2**:199. 1837.—*Scirpus dioecus* (Kunth) Boeck.
dipsacea R. & S. Syst. Veg. **2**:119. 1817.—*Fimbristylis dipsacea* Benth. & Hook.
dissoluta Kunth, Enum. Pl. **2**:219. 1837.—*Scirpus digitatus* (Nees) Boeck.
disticha Boeck. Flora **41**:415. 1858.—*Scirpus subdistichus* Boeck.
divaricata Dietr. Sp. Pl. **2**:131. 1833; **1**:197. 1840.—*Scirpus divaricatus* Elliott.
dregeana Kunth, Enum. Pl. **2**:204. 1837.—*Scirpus hystrix* Thunb.
drummondii Torr. & Hook. ex Torr. in Ann. Lyc. N. York. **3**:350. 1836.—*Fimbristylis drummondii* (Torr. & Hook.) Britton.
dubia Kunth, Enum. Pl. **2**:216. 1837.—*Scirpus digitatus* (Nees) Boeck.
dura Zoll. & Mor. Syst. Verz. Zoll. 97. 1845-46.—*Fimbristylis asperrima* Boeck.
echinidium Nees, Linnaea **9**:291. 1834.—*Scirpus incomtulus* (Nees) Boeck.
echinocephala Oliver, Trans. Linn. Soc. **29**:167. 1875.—*Scirpus cubensis* Poeppig & Kunth var. *gracilis* (Boeck.) Beetle.
echinulata Kunth, Enum. Pl. **2**: 205. 1837.—*Cyperus aristatus* Rottb.
ecklonea Schrad. Anal. Fl. Cap. 20. 1832.—*Ficinia ecklonea* (Steud.) Nees.
ecklioniana Nees, Linnaea **7**:506. 1832.—*Ficinia ecklonea* (Steud.) Nees.
ecklioniana Schrad. Anal. Fl. Cap. 15. 1832.—*Ficinia verrucosulus* (Nees) Steud.
ecklioniana var. b. Nees, Linnaea **7**:506. 1832—*Ficinia paradoxa* Nees.

ecklonii A. Dietr. Sp. Pl. **2**:116. 1833; **1**:195. 1840.—*Ficinia ecklonea* (Steud.) Nees.
ehrenbergii Otto, in Sweet, Hort. Brit. ed. II. 550. 1830.—*Nomen subnudum et dubium.*
elachista Schult. in R. & S. Syst. Veg. **2**:61. 1824.—*Fimbristylis dipsacea* Benth. & Hook.
elliottii A. Dietr. Sp. Pl. **2**:131. 1833; **1**:197. 1840.—*Fimbristylis diphylla* (Retz) Vahl.
elongantha C. A. Mey. in Ledeb. Fl. Alt. **1**:64. 1829.—*Scirpus pumilus* Vahl.
elongata of authors (e.g. Steud. Nom. Bot. **1**:826. 1840)—*Isolepis elongantha* C. A. Mey.
erubescens Presl ms. acc. Clarke, Cyp. Chil. Bot. Jahrb. von Engler **30**:29. 1901.—*Scirpus cernuus* Vahl.
erubescens Steud. Flora **25**:604. 1842.—*Scirpus cernuus* Vahl.
erythronegma Steud. Syn. Pl. Glum. Pars. II. Cyp. 96. 1855—*Scirpus prolifer* Rottb.
exigua Hook. & Arn. Bot. Beech. Voy. 312. 1841.—*Eleocharis acicularis* (L.) R. & S.
exilis H. B. K. Nov. Gen. et Sp. **1**:224. 1816.—*Fimbristylis exilis* (Willd.) R. & S.
exilis Nees, Linnaea **9**:291. 1834.—*Scirpus incomtulus* (Nees) Boeck.
expallescens Kunth, in Dur. & Schinz, Consp. Flor. Afr. **5**:630. 1895.—*Scirpus setaceus* L.
exserens Bluff, in Nees & Schauer, Consp. Fl. Germ. i. I. 81. 1836.—*Scirpus holoschoenus* L.
falcata R. & S. Syst. Veg. **2**:118. 1817.—*Bulbostylis junciformis* (HBK) Lindm.
fascicularis Kunth, Enum. Pl. **2**:188. 1837. *Scirpus fluitans* L. var. *fascicularis* (Nees) Boeck.
fascicularis Sieber (Fl. Seneg. Wall. Cat. n. 3481) Kunth, Enum. Pl. **2**:209. 1837.—*Bulbostylis barbata* (Rottb.) Clarke.
ferruginea Link, Hort. Reg. Berol. 315. 1827.—*Fimbristylis ferruginea* (L.) Vahl.
festucoides Kunth, Enum. Pl. **2**:207. 1837.—*Bulbostylis festucoides* (Poir.) Clarke.
fibrosa Nees, Linnaea **9**:292. 1834.—*Ficinia tenuifolia* Kunth.
ficinioides Kunth in Steud. Syn. Pl. Glum. Pars. II. Cyp. 98. 1855.—*Ficinia tenuifolia* Kunth.
filamentosa Nees, Linnaea **7**:503. 1832.—*Ficinia tenuifolia* Kunth.
filamentosa R. & S. Syst. Veg. **2**:113. 1817.—*Bulbostylis filamentosa* (Vahl) C. B. Clarke.
filamentosa Vahl, var. spic. *pallidis* Kunth, Enum. **2**:262. 1837; R. & S., Syn. Veg. **2**:113. 1817 excl. syn.-*Ficinia tenuifolia* Kunth var. b. *latinux* acc. to Pfeiff. Rev. der Gattung *Ficinia* Schrad. 25. 1920.
filiformis Bluff, Nees & Schauer, Consp. Fl. Germ. i I. 81. 1836.—*Scirpus holoschoenus* L.
filiformis R. & S. Syst. Veg. **2**:106. 1817.—*Eleocharis tenuis* (Willd.) Schult.
fimbriata Schrad. ex Nees, in Mart. Fl. Bras. **2**:1. 88. 1840.—*Bulbostylis fimbriata* (Schrad.) C. B. Clarke.
fistulosis Forsk. Fl. Aegyp-arab. 14. 1775.—*Scirpus fistulosus* Delile.
fluitans R. Br. Prod. Fl. N. Holl. **1**:221. 1810.—*Scirpus fluitans* L.
foenicularis Schrad. in Boeckl. Linnaea **36**:752. 1870.—*Bulbostylis barbata* (Rottb.) C. B. Clarke.
foliosa Link, Reg. Hort. Berol. 315. 1827.—*Fimbristylis foliosa* Link.
fontana Steud. Syn. Pl. Glum. Pars. II. Cyp. 97. 1855.—*Scirpus holoschoenus* L.
funckii Steud. Syn. Pl. Glum. Pars. II. Cyp. 91. 1855.—*Bulbostylis funckii* (Steud.) C. B. Clarke.
furcata Nees & Meyen in Nov. Act. Nat. Cur. **19**: Supl. I, 88. 1843.—*Scirpus cernuus* Vahl.
fusca Link, Jahrb. I. III. 79. 1820.—*Bulbostylis capillaris* (L.) C. B. Clarke.
fuscata Nees & Meyen in Boeck. Linnaea **36**:500-502. 1870.—*Scirpus cernuus* Vahl.
fuscata Nees, Linnaea **9**:291. 1834.—*Scirpus cernuus* Vahl.
fuscescens Steud. Syn. Pl. Glum. Pars II. Cyp. 92. 1855.—*Scirpus cernuus* Vahl.
fuscopurpurea Steud. Syn. Pl. Glum. Pars. II. Cyp. 99. 1855.—*Eleocharis maculosa* (Vahl) R. & S.
gardneriana Steud. Syn. Pl. Glum. Pars II. Cyp. 99. 1855.—*Bulbostylis gardneriana* (Steud.) Beetle.
gaudichaudiana Kunth, Enum. Pl. **2**:201. 1837.—*Scirpus inundatus* Poir.

giganteus Roxb. in Wight, Contrib. Bot. Ind. 110. 1834.—*Scirpus grossus* L. f.
giraudyi Steud. Syn. Pl. Glum. Pars II. Cyp. 91. 1855.—*Scirpus fluitans* L.
glaucescens Schrad. & Schult. in R. & S. Syst. Veg. **2**: mant. 69. 1824.—*Fimbristylis squarrosa* Vahl.
globosa J. Buch. Trans. N. Z. Inst. **3**:211. 1871.—*Scirpus prolifer* Rottb.
globifera Nyman, Syll. Fl. Eur. 391. 1855.—*Scirpus holoschoenus* L.
globulifera Steud. Syn. Pl. Glum. vars. II. Cyp. 97. 1855.—*Scirpus holoschoenus* L.
globulosa R. & S. Syst. Veg. **2**:119. 1817.—*Fimbristylis globulosa* (Retz) Kunth.
glomerata Schrad. ex. Schult. in R. & S. Syst. Veg. **2**: mant. 67. 1824.—*Fimbristylis spathacea* Roth.
gracillima Nyman, Consp. 768. 1882.—*Scirpus setaceus* L.
gracilis HBK, Nov. Gen. et Sp. **1**: 224. 1816.—*Fimbristylis autumnalis* (L.) R. & S.
gracilis Hort. acc. Bailey, Man. Cult. Plants 123. 1925.—*Scirpus cernuus* Vahl
gracilis Nees, Linnaea **8**:91. 1833.—*Ficinia gracilis* (Poir.) Schrad.
gracilis Nees in Wight, Contrib. Bot. Ind. 109. 1834.—*Bulbostylis puberula* (Poir.) C. B. Clarke.
gracilis Sweet, Hort. Brit. ed. I. 438. 1827.—*Scirpus nodosus* Rottb.
gracillima Hochst. ex Engl. in Abh. Preuss. Akad. Wiss. 148. 1892.—*Bulbostylis capillaris* (L.) C. B. Clarke.
grandispica Steud. Syn. Pl. Glum. Pars II. Cyp. 318. 1855.—*Scirpus maritimus* L.
gunnii Steud. Syn. Pl. Glum. Pars II. Cyp. 94. 1855.—*Scirpus inundatus* Poir.
haenkii Presl, Rel. Haenk. **1**:187. 1828.—*Fimbristylis spathacea* Roth.
hamulosa Kunth, Enum. Pl. **2**:204. 1837.—*Cyperus hamulosa* M. Bieb.
hartmanni Steud. Syn. Pl. Glum. Pars. II. Cyp. 100. 1855.—*Fimbristylis vahlii* (Lam.) Link.
hemisphaerica A. Dietr. Sp. Pl. **2**:109. 1833; **1**:194. 1840.—*Scirpus isolepis* (Nees) Boeck.
heterolepis Steud. Flora **25**: 602. 1842.—*Scirpus cernuus* Vahl.
heterolepis Steud. Syn. Pl. Glum. Pars. II. Cyp. 93. 1855.—*Carex berteroana* Desv.
heteromorpha Steud. Syn. Pl. Glum. Pars. II. Cyp. 100. 1855.—*Eleocharis melanostachya* (d'Urville) Clarke.
heterophylla Steud. Flora **25**:603. 1842.—*Scirpus cernuus* Vahl.
hirta HBK. Nov. Gen. et Sp. **1**:224. 1816.—*Fimbristylis squarrosa* Vahl.
hirtella Schrad. ex Schult. in R. & S. Syst. Veg. **2**: mant. 70. 1824.—*Bulbostylis hirtella* Nees.
hispida Liebm. in Steud. Syn. Pl. Glum. Pars. II. Cyp. 104. 1855.—*Bulbostylis hispida* (Steud.) Beetle.
holoschoenus Meliss, St. Hel. 344. 1875.—*Scirpus nodosus* Rottb.
holoschoenus R. & S. Syst. Veg. **2**:115. 1817.—*Scirpus holoschoenus* L.
hookeri Nees ex Boeck. Linnaea **36**:498. 1870.—*Scirpus koilolepis* (Steud.) Gleason.
hookeriana Boeck. Flora **91**:418. 1858.—*Scirpus setaceus* L.
humboldtii R. & S. Syst. Veg. **2**:112. 1817.—*Hemicarpha micrantha* (Vahl) Pax.
humilis Kunth, Enum. Pl. 207. 1837.—*Bulbostylis humilis* (Kunth) C. B. Clarke.
humillima Hochst. in Dur. & Schinz, Consp. Flor. Afr. **5**:616. 1895.—*Bulbostylis striatella* C. B. Clarke.
hystrix Kunth, Enum. Pl. **2**:204. 1837.—*Scirpus hystrix* Thunb.
hystrix Schrad. Linnaea **9**:290. 1834—*Scirpus rivularis* Schrad.
ignorata Nees, Linnaea **7**:501. 1832.—*Ficinia acuminata* (Steud.) Nees.
inclinata Delile, Fl. Aegypt. Illus. 50. 1813.—*Scirpus inclinatus* Aschers. & Schweinf. ex Boiss.
incomtula Nees, Linnaea **9**:291. 1834; **10**:154. 1835-36.—*Scirpus incomtulus* (Nees) Boeck.
incurvata Nees in Wight Contrib. 108. 1834.—*Scirpus articulatus* L.
intricata Steud. Syn. Pl. Glum. Pars. II. Cyp. 91. 1855.—*Scirpus fluitans* L.
inundata R. Br. Prod. Fl. Nov. Holl. 222. 1810.—*Scirpus inundatus* Poir.
involucellata (Steud. in Zoll. Syst. Verz. Ind. Arch. **2**:62. 1854, *nomen*) Steud. Syn. Pl. Glum. Pars II. Cyp. 101. 1855.—*Bulbostylis barbata* (Rottb.) C. B. Clarke
junciformis H. B. K. Nov. Gen. et Sp. **1**:222. 1816.—*Bulbostylis junciformis* (HBK) Lindman.
juncoides Miq. Fl. Ind. Bot. **3**:312. 1856-59.—*Scirpus erectus* Poir.

kochii Steud. Syn. Pl. Glum. Pars. II. Cyp. 93. 1855.—*Scirpus cernuus* Vahl.
koilolepis H. & A. in Torr. Ann. Lyc. **3**:349. 1836.—*Scirpus koilolepis* (Steud.) Gleason.
krausei Phil. Linnaea **30**:203. 1859-60.—*Schoenus nitens* Boeck. var. *krausei* (Phil.) Kük.
kunthiana Steud. Syn. Pl. Glum. Pars. II. Cyp. 95. 1855.—*Scirpus incomtulus* (Nees) Boeck.
kyllingia Nees in Boeck. Linnaea **36**:733. 1870.—*Scirpus kyllingioides* (Rich.) Boeck.
kyllingioides A. Rich. Tent. Fl. Abyss. **2**:502. 1847-51.—*Scirpus kyllingioides* (Rich) Boeck.
labillardieri Steud. Syn. Pl. Glum. Pars II. Cyp. 96. 1855.—*Bulbostylis labillardieri* (Steud.) Beetle.
laciniata Eckl. ex Kunth, in Dur. & Schinz, Consp. Flor. Afr. **5**:637. 1895.—*Ficinia ecklonea* (Steud.) Nees.
lanata HBK. Nov. Gen. et Sp. **1**:220. f. 68. 1815.—*Bulbostylis lanata* (HBK) C. B. Clarke.
langsdorffiana Kunth, Enum. Pl. **2**:214. 1837.—*Bulbostylis langsdorffiana* (Kunth) C. B. Clarke.
latifolia A. Dietr. Sp. Pl. **2**:132. 1833; **1**:197. 1840.—*Pleurostachys elegans* Kunth.
lenticularis Nees in Boeck. Linnaea **36**:500-502. 1869-70.—*Scirpus cernuus* Vahl.
lenticularis R. Br. Prod. Fl. Nov. Holl. 222. 1810.—*Scirpus lenticularis* Poir.
lepida Nees in Boeck. Linnaea **36**:500-502. 1870.—*Scirpus cernuus* Vahl.
leptalea Schultes in R. & S. Syst. Veg. **2**: mant. 62. 1824.—*Scirpus cernuus* Vahl.
leptocaulis Torr. Bot. Whipple Exped. 97. 1857.—*Scirpus cernuus* Vahl var. *californicus* (Torr.) Beetle
leptos Steud. Syn. Pl. Glum. Pars. II. Cyp. 91. 1855.—*Eleocharis leptos* (Steud.) Svenson.
leptostachya Kunth, Enum. Pl. **2**:190. 1837.—*Scirpus leptostachyus* (Kunth) Boeck.
lereschii Schuttlw. in Parl. Fl. Ital. **2**:68. 1852.—*Eleocharis artopurpurea* (Retz) Kunth.
leucostachya HBK, Nov. Gen. et Sp. **1**:220. 1816.—*Bulbostylis leucostachya* (HBK) C. B. Clarke.
lichtensteiniana Kunth, Enum. Pl. **2**:207. 1837.—*Bulbostylis lichtensteiniana* (Kunth) C. B. Clarke.
lineata Nees, Linnaea **10**:160. 1836; Kunth, Enum. Pl. **2**:215. 1837.—*Ficinia gracilis* Schrad.
lineata Nees var. y *pumila* Nees mss. (ex Kunth) in Dur. & Schinz. Consp. Flor. Afr. **5**:617. 1895.—*Scirpus antarcticus* L.
lineata R. & S. Syst. Veg. **2**:117. 1817.—*Scirpus lineatus* Michx.
linnaei Bluff, Nees & Schauer, Consp. Fl. Germ. i. I. 82. 1836.—*Scirpus holoschoenus* L.
longifolia Nees, Linnaea **9**:290. 1834.—*nomen nudum et dubium.*
longifolia Steud. Syn. Pl. Glum. Pars II. Cyp. 90. 1855.—*Eleocharis acicularis* (L.) R. & S. var. *gracilescens* Svenson.
longispica Steud. Syn. Pl. Glum. Pars. II. Cyp. 104. 1855.—*Fimbristylis fusca* Benth. Hook. f.
ludwigii Kunth, Enum. Pl. **2**:189. 1837.—*Scirpus ludwigii* (Steud.) Boeck.
lupulina Nees in Wight, Contrib. 107. 1834.—*Scirpus roylei* (Wight) Beetle.
magellanica Gaudich. Freyc. Voy. Bot. 414. 1826.—*Scirpus cernuus* Vahl.
margaritifera Nees, Ann. & Mag. Nat. Hist. Ser. I. vi. 46. 1841.—*Schoenus apogon* R. & S.
marginata A. Dietr. Sp. Pl. **2**:110. 1833.—*Ficinia filiformis* (Lam.) Schrad. **1**:194. 1840.
martiana Schrad. ex Nees, in Mart. Fl. Bras. **2**:I. 84. 1840.—*Scirpus digitatus* (Nees) Boeck.
martii R. & S. Syst. Veg. **2**:117. 1817.—*Cladium giganteum* Willk.
maxima A. Dietr. Sp. Pl. **2**:130. 1833; **1**:197. 1840—*Scirpus grossus* L. f.
megapotomica A. Dietr. Sp. Pl. **2**:132. 1833; **1**:197. 1840.—*Pycreus megapotamicus* Nees.

membranacea Nees, Linnaea **9**:291. 1834; **10**:159. 1836.—*Scirpus membranacea* Thunb.
membranacea Nees var. *trispicata* (Thunb.) Nees, Linnaea **10**:159. 1836.—*Scirpus membranaceus* Thunb.
mesantha Nees, Linnaea **9**:291. 1834.—*Scirpus supinus* L.
meyeniana Nees, Linnaea **9**:291. 1834.—*Scirpus cernuus* Vahl.
micheliana Benth. in Hook. Niger Fl. 553. 1849.—*Cyperus michelianus* (L.) Link.
micheliana R. & S. Syst. Veg. **2**:114. 1817.—*Cyperus pygmaeus* Rottb.
micrantha R. & S. Syst. Veg. **2**:110. 1817.—*Hemicarpha micrantha* (Vahl) Pax.
microcarpa Nees, Linnaea **10**:150. 1836.—*Scirpus cernuus* Vahl.
microstachys Phil. ms. acc. to Clarke, Cyp. Chil. Bot. Jahrb. von Engl. **30**:27. 1901.—*Scirpus cernuus* Vahl.
miliacea Link, Hort. Reg. Bot. Berol. 316. 1827.—*Fimbristylis miliacea* (L.) Vahl.
miliacea Presl, Rel. Haenk. **1**:189. 1828.—*Fimbristylis miliacea* (L.) Vahl.
minaae Parl, Giorn. Bot. Ital. **2**:I. 146. 1846; Fl. Palerm. **1**:308. 1845.—*Scirpus cernuus* Vahl.
minace (sic) Parl in Steud. Syn. Pl. Glum. Pars. II. Cyp. 93. 1855. *Isolepis minaae* Parl.
minima Schrad. Anal. Fl. Cap. 17. 1832.—*Scirpus isolepis* (Nees) Boeck.
minima Schrad. Goett. Gel. Anzeig. III. 2068. 1821.—*Ficinia filiformis.*
modesta Philippi, Linnaea **29**:79. 1857-58.—*Scirpus cernuus* Vahl.
monandra Link, Jahrb. *i*:III. 78. 1820.—*Eleocharis atropurpurea* (Retz) Kunth.
monocephala Steud. Syn. Pl. Glum. Pars II. Cyp. 97. 1855.—*Ficinia brevifolia*
monostachya Phil. Pfl. Antofagasta 79. 1891.—*Scirpus cernuus* Vahl.
monostachya Spreng. Neue Entdeck. **3**:11. 1822.—*Fimbristylis schoenoides* Vahl.
mucronata Fourr. Am. Soc. Linn. Lyon. N.S. **17**:173. 1869.—*Scirpus mucronatus* L.
muehlenbergii A. Dietr. Sp. Pl. **2**:106. 1833; **1**:193. 1840.—*Bulbostylis capillaris* (L.) C. B. Clarke.
multicaulis Schldl Linnaea **20**:562. 1847.—*Scirpus cernuus* Vahl.
multinervosa Boeck. Flora **91**:418. 1858.—*Scirpus inundatus* Poir.
nana Link, Hort Berol. I. 285. 1827.—*Eleocharis parvula* (R. & S.) Link.
nana Phil. Linnaea **29**:79. 1857-58.—*Scirpus inundatus* Poir.
natans A. Dietr. Sp. Pl. **2**:106. 1833.—*Scirpus rivularis* (Schrad.) Boeck.
nervosa Hochst. Schimp. it. Abyss. II. 559. A. Rich. Tent. Fl. Abyss. II. 499. 1846—*Scirpus cernuus* Vahl.
nigrescens Steud. Syn. Pl. Glum. Pars. II. Cyp. 91. 1855.—*Eleocharis nigrescens* (Nees) Steud.
nigricans HBK, Nov. Gen. et Sp. **1**: 220. 1815.—*Scirpus inundatus* Poir.
nitens R. & S. Syst. Veg. **2**:117. 1817.—*Rhynchospora nitens* (Vahl) A. Gray.
nodosa R. Br. Prod. Fl. Nov. Holl. 221. 1810.—*Scirpus nodosus* Rottb.
notata Nees, in Lehm. Pl. Preiss. **2**:74. 1844-47.—*Scirpus antarcticus* L.
novae-zealandiae Colenso, Trans. N. Zel. Inst. **21**:102. 1889.—*Scirpus basilaris* (Hook. f.) C. B. Clarke
nuda Nees in Boeck. Linnaea **36**:500-502. 1869-70.—*Scirpus cernuus* Vahl.
nudipes Kunth, Enum. Pl. **2**:206. 1837.—*Eleocharis nudipes* (Kunth) Palla.
numidiana R. & S. Syst. Veg. **2**:106. 1817.—*Scirpus cernuus* Vahl.
obtusifolia P. Beauv. Fl. d'Oware **2**:38. 1807.—*Fimbristylis obtusifolia* (Lam.) Kunth.
oligantha C. A. Mey. Cyp. Nov. 3, t: 1. 1830.—*Scirpus pumilus* Vahl.
oligantha Nees, Linnaea **7**:503. 1832.—Ficinia filiformis (Lam.) Schrad.
oreophila Phil. Anal. Mus. Nac. Chile Bot. 79. 1891.—*Scirpus nevadensis* Wats.
oryzetorum Steud. Syn. Pl. Glum. Pars. II. Cyp. 96. 1855.—*Scirpus uninodis* (Delile) Beetle.
ottonis Boeck. Flora **41**:419. 1858.—*Bulbostylis ottonis* (Boeck.) Beetle.
pallescens A. Dietr. Sp. Pl. **2**:121. 1833; **1**:195, 1840.—*Fimbristylis dichotoma* (R. & S.) Vahl.
pallida Nees, Linnaea **8**:81. 1833.—*Scirpus rivularis* (Schrad.) Boeck.
paludicola Kunth, Enum. Pl. **2**:198. 1837.—*Scirpus paludicolus* Kunth.
palustris Schrad. Anal. Cap. Cyp. 17. t. 1. f. 7. 1832.—*Scirpus rivularis* (Schrad.) Boeck.

panamensis Presl, Reliq. Haenk. **1**:351. 1828.—*Rhynchospora exilis* R. & S.
paniculata S. F. Gray, Nat. Arr. Brit. Pl. **2**:78. 1821.—*Scirpus holoschoenus* L.
paniculata var. *romana* op. cit. 79. 1821.—*Scirpus holoschoenus* L.
panormitana Parlat. Giorn. Bot. **2**:146. 1846.—*Scirpus holoschoenus* L.
paradoxa Kunth, Enum. Pl. **2**:206. 1837.—*Bulbostylis paradoxa* Nees.
paradoxa Schrad. in Goett. Gel. Anz. **3**:2068. 1821.—*Ficinia paradoxa* Nees.
paraensis Schrad. ex Nees, Mart. Fl. Bras. **2**:I. 86. 1840.—*Bulbostylis paraensis* C. B. Clarke.
parvula Link, Hort. Reg. Bot. Berol. 314. 1827.—*Eleocharis parvula* (R. & S.) Link.
pauciflora Liebm. in Steud. Syn. Pl. Glum. Pars. II. Cyp. 104. 1855.—*Bulbostylis pauciflora* (Steud.) C. B. Clarke.
pentagona Schult. in R. & S. Syst. Veg. **2**:mant. 69. 1824.—*Fimbristylis quinquangularis* Kunth.
pentasticha Boeck. Flora **42**:446. 1859.—*Scirpus supinus* L.
perpusilla Nees, Linnaea **9**:291. 1834.—*Scirpus cernuus* Vahl.
perpusilla Phil. Anal. Univ. Chil. 555. 1873.—*Scirpus perpusillus* Boeck.
perrottetii Steud. Syn. Pl. Glum. Pars II. Cyp. 318. 1855.—*Fimbristylis exilis* (Willd.) R. & S.
phaeocarpa Nees, Linnaea **10**:153. 1835-36.—*Scirpus antarcticus* L.
pholiodes Steud. Syn. Pl. Glum. Pars II, Cyp. 93. 1855.—*Scirpus cernuus* Vahl.
pilosa Steud. Syn. Pl. Glum. Pars II, Cyp. 97, 1855.—*Bulbostylis pilosa* (Steud.) Beetle.
planifolia Spreng. Neue Entdeck **3**:10. 1822.—*Scirpus planifolius* Muhl.
plebeia Schrad. Anal Fl. Cap. 18. 1832.—*Scirpus setaceus* L. and *Scirpus antarcticus* L.
pleurocarpa Hoschst. in Dur. & Schinz, Consp. Flor. Afr. **5**:630. 1895.—*Scirpus setaceus* L.
podocarpa Boeck. Flora **43**:179. 1860.—*Fimbristylis vexata* Steud.
pohliana Boeck. Flora **41**:596. 1858.—*Bulbostylis pohliana* (Boeck.) Beetle.
poiretii R. & S. Syst. Veg. **2**:116. 1817.—*Scirpus holoschoenus* L.
poiretii Steud. Syn. Pl. Glum. Pars. II. Cyp. 98. 1855.—*Ficinia gracilis* (Poir.) Schrad.
polycolea DeNot. Am. Sc. Nat. Ser. III. **9**:326. 1848.—*Scirpus supinus* L.
polyphylla A. Rich. Tent. Fl. Abyss. **2**:503. 1847-51.—*Scirpus steudneri* Boeck.
praelongata Nees in Wight. Contrib. 108. 1834.—*Scirpus articulatus* L.
praeusta Nees in Dur. & Schinz, Consp. Fl. Afr. **5**:639. 1895.—*Ficinia laevis* Nees.
preslii A. Dietr. Sp. Pl. **2**:129. 1833; **1**:196. 1840.—*Rhynchospora exilis* R. & S.
prolifera R. Br. Prod. Fl. Nov. Holl. 223. 1810.—*Scirpus prolifer* Rottb.
prolifera Carmich. Trans. Linn. Soc. **12**:503. 1819.—*Scirpus thouarsianus* Schult.
prolifera Hook. f. Fl. N. Zel. **1**:271. 1867.—*Scirpus inundatus* Poir.
prolifera Melliss, St. Hel. 344. 1875.—*Scirpus cernuus* Vahl.
prolongata Nees in Wight, Contrib. 108. 1834.—*Scirpus articulatus* L.
propinqua Nees, Ann. & Mag. Nat. Hist. Ser. I. vi. 46. 1841.—*Scirpus antarcticus* L.
propinqua R. B. Prod. Fl. Nov. Holl. 222.1810.—*Scirpus inundatus* Poir.
proxima Steud. Syn. Pl. Glum. Pars II. Cyp. 95. 1855.—*Scirpus supinus* L.
pseudo-junciformis Boeck. Flora **40**:35. 1857.—*Bulbostylis pseudo-junciformis* (Boeck.) Beetle.
pseudoschoenus A. Dietr. Sp. Pl. **2**:103. 1833; **1**:193. 1840.—*Ficinia tristachya* Nees.
psilocarpa Kunth, Enum. Pl. **2**:193. 1837.—*Scirpus inundatus* Poir.
psilocarpa Kuntze, Poepp. Coll. II. 12. —*Scirpus inundatus* Poir.
ptycholeptos Steud. Syn. Pl. Glum. Pars. II. Cyp. 93. 1855.—*Scirpus verrucosulus* (Nees) Steud.
puberula Kunth, Enum. Pl. **2**:213. 1837.—*Bulbostylis puberula* (Poir.) C. B. Clarke.
puberula Nees, Linnaea **9**: 291. 1834.—*Bulbostylis puberula* (Poir.) C. B. Clarke.
pubescens R. & S. Syst. Veg. **2**:118. 1817.—*Fuirena pubescens* Kunth.
pubiculmis Boeck. Linnaea **37**:28. 1871-73.—*Fimbristylis exilis* (Willd.) R. & S.
pubiculmis Hochst. in Dur. & Schinz, Consp. Flor. Afr. **5**:605. 1895.—*Fimbristylis exilis* (Willd.) R. & S.
pubigera Reichb. ex Kunth, Enum. Pl. **2**:227. 1837.—*Fimbristylis exilis* (Willd.) R. & S.
pubigera Schrad. Pl. Rar. Hort. Goett. **1**. 1809. ex Schult. Mant. **2**:476. 1824.—*Fimbristylis dichotoma* (R. & S.) Vahl.

pulchella Thw. Enum. Pl. Zeyl. 350. 1864.—*Fimbristylis pulchella* Trim.
pumila Link, Hort. Berol. **1**:286. 1827.—*Scirpus cernuus* Vahl.
pumila R. & S. Syst. Veg. **2**:106. 1817.—*Scirpus pumilus* Vahl.
pumila Steud. Syn. Pl. Glum. Pars II. Cyp. 90. 1855.—*Ficinia filiformis* (Lam.) Schrad.
pumilo Boeck. Flora **42**:448. 1859.—*Scirpus cernuus* Vahl.
punctulata Steud. Syn. Pl. Glum. Pars. II. Cyp. 92. 1855.—*Scirpus cernuus* Vahl.
purpurascens Steud. Syn. Pl. Glum. Pars. II. Cyp. 92. 1955.—*Scirpus cernuus* Vahl.
pusilla Kunth, Enum. Pl. **2**:190. 1837.—*Scirpus africanus* Beetle.
pygmaea Kunth, Enum. Pl. **2**:191. 1837.—*Scirpus cernuus* Vahl.
pygmaea var. *californica* Torr. Bot. Wilkes Exped. 476. 1874.—*Scirpus cernuus* Vahl var. *californicus* (Torr.) Beetle.
racemosa Schult. in R. & S. Syst. Veg. **2**: mant. 532. 1827.—*Scirpus racemosus* Spreng.
radiata R. & S. Syst. Veg. **2**:113. 1817.—*Ficinia radiata* (L.f.) Kunth.
radiciflora Steud. Syn. Pl. Glum. Pars II. Cyp. 318. 1855.—*Bulbostylis capillaris* (L.) C. B. Clarke.
ramulosa Steud. in Lechl. Berb. Am. Austr. 50.—*Scirpus inundatus* Poir.
rariflora Schrad. ex Schult. in R. & S. Syst. Veg. **2**: mant. 61. 1824.—*Fimbristylis schoenoides* Vahl.
repens Nees, Linnaea **9**:291. 1834.—*Scirpus repens* (Nees) Kunth.
reticularis Colenso, Trans. N. Z. Inst. **18**:277. 1886.—*Scirpus inundatus* Poir.
rigescens Presl, in Oken, Isis **21**:268. 1828.—*Fimbristylis spathacea* Roth.
rigida Steud. Linnaea **36**:492. 1870.—*Scirpus rigidus* Boeck.
riparia R. Br. Prod. Fl. Nov. Holl. **1**:222. 1810.—*Scirpus cernuus* Vahl.
rivularis Schrad. Anal. Cap. Cyp. t. 1. f. 5. 1832.—*Scirpus rivularis* Schrad.
robustula Steud. Syn. Pl. Glum. Pars. II. Cyp. 90. 1855.—*Scirpus striatus* (Nees) Beetle.
romana R. & S. ex G. Don. in Lond. Hort. Brit. 21. 1831-1838.—*Scirpus holoschoenus* L.
roylei Wight. Contrib. 107. 1834.— *Scirpus roylei* (Wight) Beetle
rubescens Presl, Delic. Prag. 157. 1832.—*Bulbostlis* (a perennial from Brazil. Dr. 92.)
rubicunda Kunth, Enum. Pl. **2**:188. 1837.—*Scirpus rubicundus* (Nees) Beetle.
rugosa Boeck. Linnaea **36**:702. 1870.—*Scirpus articulatus* L.
rugosua Hochst. ex C. B. Clarke in T. Dur. & Schinz. Consp. Fl. Afr. **5**:618. 1893-95. —*Scirpus articulatus* L.
rupestris Kunth, Enum. Pl. **2**:193. 1837.—*Scirpus cernuus* Vahl.
saviana Link, Hort. Berol. **1**:285. 1827.—*Scirpus setaceus* L.
saviana Schult. in R. & S. Syst. Veg. **2**:63. 1824.—*Scirpus cernuus* Vahl.
savii Fourr. Ann. Soc. Linn. Lyon. N.S. 17. 174. 1869.—*Scirpus cernuus* Vahl.
scabra Presl in Steud. Nom. Bot. ed. II. 828. 1840.—*Bulbostylis capillaris* (L.) C. B. Clarke.
scariosa Nees, Linnaea **7**:501. 1832.—*Ficinia scariosa* (Vahl) Nees.
schimperiana A. Rich. Tent. Fl. Abyss. **2**:501, 1851.—*Bulbostylis schimperiana* (A. Rich) Clarke.
schoenoides Kunth, Enum. Pl. **2**:208. 1837.—*Bulbostylis schoenoides* (Kunth) Clarke.
schomburghii Steud. Syn. Pl. Glum. Pars II. Cyp. 102. 1855.—*Fimbristylis aestivalis* Vahl.
schraderi A. Dietr. Sp. Pl. **2**:120. 1833; **1**:195. 1840.—*Fimbristylis spathacea* Roth.
schraderiana Steud. Syn. Pl. Glum. Pars II. Cyp. 96. 1855.—*Bulbostylis schraderiana* (Steud.) Beetle.
schweinfurthiana Oliv. Trans. Linn. Soc. **29**:167. 1875.—*Fimbristylis exilis* (Willd.) R. & S.
sellowiana Kunth, Enum. Pl. 2: 208. 1836.—*Fimbristylis sellowiana* (Kunth) Hauman
semipedunculata Boeck. Flora **61**:417. 1858.—*Scirpus antarcticus* L.
snegalensis Hochst. ex. Steud. Syn. Pl. Glum. Pars II. Cyp. 96. 1855.—*Scirpus fistulosus* Delile.
sepulcralis Steud. Syn. Pl. Glum. Pars. II. Cyp. 94. 1855.—*Scirpus cernuus* Vahl.
seslerioides Kunth, Enum. Pl. **2**:195. 1837.—*Scirpus antarcticus* L.
setacea Nees, Linnaea **10**:151. 1835-36.—*Scirpus antarcticus* L.
setacea R. Br. Prod. Fl. N. Holl. **1**:222. 1810.—*Scirpus setaceus* L.

setaceus (L.) R. Br. var. *abyssinica* Boeck. Flora **41**:419. 1858.—*Scirpus setaceus* L. or *Ficinia costata* (Hochst ex A. Rich) Pfeiff. acc. Pfeiff. 22. 1920.

setosa Raoul ex A. Rich. Voy. Astrol. Bot. 104. 1832-34.—*Scirpus cernuus* Vahl.

setifolia R. Rich. Tent. Fl. Abyss. **2**:498.1851.—*Eleocharis atropurpurea* (Retz) Kunth.

sicula Presl, Cyp. Gram. Sicul. 13. 1820.—*Scirpus cernuus* Vahl.

sieberi Schrad. Anal. Fl. Cap. 23. 1832.—*Bulbostylis puberula* (Poir.) Clarke.

simillima Steud. Syn. Pl. Glum. Pars II. Cyp. 95. 1855.—*Scirpus supinus* L.

sororia Kunth, Enum. Pl. **2**:192. 1837.—*Scirpus cernuus* Vahl.

spathacea Schult. in R. & S. Syst. Veg. **2**: mant. 67. 1824.—*Fimbristylis spathacea* Roth.

sphaerocarpa Nees, Linnaea **10**:153. 1836; Kunth, Enum. Pl. **2**:195. 1837.—*Scirpus antarcticus* L.

sphaerophora Ehr. in Boeckl. Linnaea **36**:721. 1870.—*Scirpus holoschoenus* L.

spiralis A. Rich. Voy. Astrol. Bot. 105. t. 19. 1832.—*Desmoschoenus frondosus* Hook. f.

squarrosa Carmich. Trans. Linn. Soc. **12**:503. 1819.—*Scirpus thouarsianus* Schult.

squarrosa HBK, Nov. Gen. et Sp. **1**:221. 1816.—*Hemicarpha micrantha* (Vahl) Pax.

squarrosa (L.) R. & S. Syst. Veg. **2**:111. 1817.—*Fimbristylis squarrosa* (L.) Vahl.

stenophylla Torr. Ann. Lyc. N. York **3**:353. 1836.—*Bulbostylis stenophylla* (Torr.) C. B. Clarke.

steudelii Schrad. Anal. Cap. Cyp. 19. 1832.—*Ficinia ecklonia* (Steud.) Nees.

striatella Steud. Syn. Pl. Glum. Pars II. Cyp. 92. 1855.—*Scirpus cernuus* Vahl.

striata Kunth, Enum. Pl. **2**:189. 1837.—*Scirpus striatus* (Nees) Beetle.

stricta A. Dietr. Sp. Pl. **2**:121. 1833; **1**:196. 1840.—*Fimbristylis spathacea* Roth.

striolata Nees ex Boeck. in C. B. Clarke in Dur. & Schinz, Consp. Flor. Afr. **5**:632. 1895.

subacaulis Steud. Syn. Pl. Glum. Pars II. Cyp. 318. 1855.—*Fimbristylis Vahlii* (Lam.) Link.

subcucullata Berggren, Minneskr. Fisiog. Sallsks. Lund 22. t. 5, f. 16-20. 1877.—*Scirpus aucklandicus* (Hook. f.) Boeck.

subsquarrosa Schrad. in R. & S. Syst. Veg. **2**: mant. 64. 1824.—*Hemicarpha micrantha* (Vahl) Pax.

subsquarrosa var. *minor* Schrad. in R. & S. Syst. Veg. **2**: mant. 64. 1824.—*Hemicarpha micrantha* (Vahl) Pax. var. *minor* (Schrad.) Friedl.

subtilis Kunth, Enum. Pl. **2**:191. 1837.—*Scirpus cernuus* Vahl.

subtilissima Boeck. Flora **41**:416. 1858.—*Scirpus cernuus* Vahl.

subtristachya Hochst. ex Boeck. Linnaea **36**:752. 1870.—*Bulbostylis barbata* (Rottb.) C. B. Clark.

substristachya Hochst. in Dur. & Schinz, Consp. Flor. Afr. **5**:611. 1895.—*Bulbostylis barbata* (Rottb.) C. B. Clarke.

sulcata Carmich. Trans. Linn. Soc. **12**:503. 1819.—*Scirpus sulcatus* Thouars.

supina R. Br. Prod. Fl. N. Holl. **1**:221. 1810.—*Scirpus supinus* L.

tenella Kunth, Enum. Pl. **2**:213. 1837.—*Fimbristylis tenella* Schult.

tenerrima Fisch. & Mey. ex. Ledeb. Fl. Ross. **4**:258. 1853, *nomen;* Steud. Syn. Pl. Glum. Pars. II. Cyp. 102. 1855.—*Bulbostylis capillaris* (L.) Clarke.

tenuifolia A. Dietr. Sp. Pl. **2**:131. 1840.—*Bulbostylis tenuifolia* Nees.

tenuior Steud. Syn. Pl. Glum. Pars. II. Cyp. 91. 1855.—*Scirpus ludwigii* (Steud.) Boeck.

tenuis Presl, Del. Prag. 145. 1822.—*Scirpus cernuus* Vahl.

tenuis Schrad. Anal. Fl. Cap. 15. 1832.—*Scirpus africanus* Beetle.

tenuissima D. Don, Fl. Nep. 40. 1825.—*Bulbostylis densa* (Wall.) Beetle.

tenuissima Nees, Linnaea **9**:291. 1834.—*Scirpus tenuissimus* (Nees) Boeck.

tetragona Schult. in R. & S. Syst. Veg. **2**: mant. 69. 1824.—*Fimbristylis miliacea* (L.) Vahl.

thouarsii Nees, Linnaea **9**:291. 1834.—*Bulbostylis puberula* (Poir.) Clarke.

thuarsii A. Dietr. Sp. Pl. **2**:109. 1840.—*Scirpus thouarsianus* Schult.

thunbergii Schrad. Goett. Gel. Anz. **3**:2068. 1821.—*Scirpus thunbergii* (Schrad.) Boeck.

trachycarpa Nees, in Boeck. Linnaea **36**:500-502. 1870.—*Scirpus cernuus* Vahl.

trachysperma Nees, Linnaea **10**:152. 1836.—*Scirpus cernuus* Vahl.

trichocaulis Phil. in Clarke, Engl. Bot. Jahrb. **30**: Beibl. **68**: 31. 1901.—*Scirpus inundatus* Poir.
trichoides Schrad. in R. & S. Syst. Veg. **2**:mant. 64. 1824.—*Bulbostylis trichoides* (R. & S.) Beetle.
trichokolea Steud in Zoll. Syst. Verz. Ind. Arch. **2**:62. 1854, *nomen;* Syn. Pl. Glum. Pars II. Cyp. 96. 1855.—*Bulbostylis trichokolea* (Steud.) Beetle.
trifida Kunth, Enum. Pl. 2:213. 1837.—*Bulbostylis capillaris* (L.) Clarke.
trigyna Kunze ex Boeck. Linnaea **36**:502. 1870.—*Scirpus cernuus* Vahl.
tristachya Phil. Linnaea **33**:203. 1866.—*Scirpus inundatus* Poir.
tristachya R. Br. Prod. Fl. N. Holl. 222. 1810.—*Bulbostylis barbata* (Rottb.) C. B. Clarke.
tristachya R. & S. Syst. Veg. **2**:110. 1817.—*Ficinia tristachya* (Rottb.) Nees.
tristachya R. & S. var. Nees, Linnaea **7**:502. 1832.—*Ficinia tristachya* (Rottb.) Nees var. *glaucescens* Boeck.
truncata Nees, Linnaea **7**:508. 1832.—*Ficinia truncata* (Thunb.) Schrad.
truncata Schrad. ex Nees in Mart. Fl. Bras. **2**:I. 83. 1841.—*Bulbostylis.*
turkestanica Regel, Act. Hort. Petrop. **7**:561. 1880.—*Fimbristylis ferruginea* (L.) Vahl.
uliginosa Koch in Steud. Syn. Pl. Glum. Pars II. Cyp. 91. 1855.—*Eleocharis acicularis* (L.) R. & S.
uncinata R. & S. Syst. Veg. **2**:111. 1817.—*Ficinia uncinata* Kunth.
uninodis Delile in Desc. Egypte **2**:152. 1812.—*Scirpus uninodis* (Delile) Beetle.
urvillei Steud. Syn. Pl. Glum. Pars. II. Cyp. 94. 1855.
vaginata Eckl. ex Steud. Nom. ed. II. 828. 1840.—*Fimbristylis ferruginea* Vahl.
vahlii HBK, Nov. Gen. et Sp. **1**:221. 1816.—*Fimbristylis vahlii* (Lam.) Link.
valdiviae Phil. in Boeck. Linnaea **36**:508. 1870.—*Scirpus inundatus* Poir.
valdiviae Steud. Syn. Pl. Glum. Pars II. Cyp. 94. 1855.—*Scirpus inundatus* Poir.
varia Schrad. ex. Nees in Mart. Fl. Bras. **2**:I. 75. 1842.—*Fimbristylis diphylla* (Retz) Vahl.
varians Steud. Syn. Pl. Glum. Pars II. Cyp. 1855.—*Scirpus inundatus* Poir.
variegata Steud. Syn. Pl. Glum. Pars II. Cyp. **2**:93. 1855.—*Carex setifolia* Kuntze
venustula Kunth, Enum. Pl. **2**:192. 1837.—*Scirpus venustulus* (Kunth) Boeck. or *Ficinia bicolor* Pfeiff. acc. Pfeiff. Rev. der Gattung *Ficinia* 27. 1920.
verrucifera Maxim. Prim. Fl. Amurens 300. 1859.—*Fimbristylis verrucifera* (Maxim.) Mak.
verrucosula Nees, Linnaea **7**:495. 1832.—*Scirpus verrucosulus* (Nees) Steud.
vestita Kunth, Enum. Pl. **2**:210. 1837.—*Bulbostylis vestita* (Kunth) C. B. Clarke.
vincentii Steud. Syn. Pl. Glum. Pars II. Cyp. 102. 1855.—*Fimbristylis vahlii* (Lam.)
vivipara Schrad. in Desv. in C. Gay, Hist. fis. y polit. Chile **6**:189. 1853.—*Scirpus inundatus* Poir.
wallichiana Schult. in R. & S. Syst. Veg. **2**: mant. 533. 1824.—*Bulbostylis wallichiana* (Schult.) Beetle.
warei Torr. Ann. Lyc. New York **3**:1836.—*Bulbostylis warei* (Torr.) C. B. Clarke.
willdenowii Kunth, Enum. Pl. **2**:210. 1837.—*Bulbostylis barbata* (Rottb.) C. B. Clarke.
willdenowii R. & S. Syst. Veg. **2**:120. 1817.—*Fimbristylis complanata* (Retz) Vahl.

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The Genus Ranunculus in West Virginia*

Frank H. Bell

The genus *Ranunculus* offers many taxonomic difficulties. The need of a comprehensive treatise became apparent when the writer began to study this group. This paper is an attempt to classify the wild species of *Ranunculus* found in West Virginia and to render their identification easier to students.

Although only specimens from the herbarium of West Virginia University were examined, it is almost certain that it contains all of the species so far discovered in the state. All specimens in the herbarium which have been considered as satisfactorily identified are cited here. Such a list should give a general idea of abundance in the state as a whole, but as collecting has been done chiefly in areas accessible to such ardent collectors as Elizabeth Ann Bartholomew, Ray Harris, John Paul Tosh, Cecil Strickland, Wilbert Frye, Mr. and Mrs. H. A. Davis, Leslie Greenlee, and others, distributional data of value can scarcely be secured. Changes in nomenclature from those of Gray's *Manual of Botany,* Seventh Edition, have been made to conform to present usage. Synomyms are given only when the accepted name differs from that of Gray's *Manual.*

An artificial key to the genus has been made and includes both those species which are known to occur in West Virginia and those which, as indicated by distribution, might be found in the state. A few introduced species that have escaped in states along the Atlantic seaboard have not been included. However, they and some of their identifying characteristics have been included in a paragraph at the end of the key. It is hoped that any user of the key in this state will have reasonable assurance that his specimen can be keyed out, whether it has already been discovered or not.

Millspaugh, in his 1913 checklist, listed 13 species in the genus for the state, while Core, in his Catalogue, lists 15 species. The present work recognizes 13 species which have been found in the state. One new species is being added to the state list—*Ranunculus pusillus.* Three species which were listed (one doubtfully) in Core's Catalogue have been omitted. The record of *R. Macounii* was based on a misidentification, the specimen being a hispid form of *R. septentrionalis. R. pennsylvanicus* was reported by Millspaugh, but the writer has been informed by the Feld Museum, where Millspaugh's herbarium is located, that no specimen of that species is there. So until a specimen is seen, this species cannot be admitted to the state flora. The third species to be omitted is *R. fascicularis.* This species was also reported by Millspaugh, and has always been considered by later writers as being in the state. A few specimens so named were in the West Virginia University

* Contribution No. 27 from the Herbarium of West Virginia University.

Herbarium, all referable to other species. This species should eventually be discovered, however.

I wish to acknowledge my indebtedness to Dr. Earl L. Core for the assistance rendered in the preparation of this treatise.

RANUNCULUS (Tourn.) L.

Some 250 species, widely distributed in the temperate and cool regions of both hemispheres, and on mountains in the tropics. The genus has been divided into several sections, a few of which have been split off by certain authors into separate genera. The latest work on the genus as a whole, and its various subdivisions, is to be found in the contributions of Lyman Benson (1, 2, 3).

KEY TO THE SPECIES

A. Leaves finely dissected; aquatics.
  B. Flowers single, opposite the leaves, white or with yellow base; leaf divisions filiform; achenes marginless, transversely wrinkled.
    C. Leaves usually petiolate, collapsing when drawn from the water; stipular sheaths mostly narrow and mostly adnate to the petiole; achene short-beaked ..... 1. *R. trichophyllus*
    C. Leaves sessile or nearly so, not collapsing when drawn from the water; stipular sheaths broad, hairy, and auricled; achene beak about 1 mm. long ..... *2. *R. longirostris*
  B. Flowers in terminal bracted racemes, yellow; leaf divisions from narrowly linear to cuneate; achenes margined, not transversely wrinkled ..... *3. *R. flabellaris*

A. Leaves not finely dissected[1]; terrestrial.
  B. Leaves all entire or denticulate, none lobed.
    C. Blades generally less than 6 cm. long and 1 cm. wide; achene beak at least not over 0.2 mm. long; annuals.
      D. Petals 1-5, about 1.5 mm. long; stamens 3-10; plants glabrous; leaves mostly entire ..... 4. *R. pusillus*
      D. Petals 5, 3-7 mm. long; stamens 20-25; plants usually somewhat appressed-pubescent ..... *5. *R. laxicaulis*
    C. Blade mostly 6-12 cm. long and 5-30 mm. wide, usually denticulate; glabrous perennial; achene beak long, although withering early ..... 6. *R. ambigens*
  B. At least the upper leaves lobed.
    C. Some or all basal leaves crenate (rarely entire).
      D. Achene with a distinct recurved beak 0.6-1 mm. long; petals $1/3$-$1/2$ the length of the sepals ..... 7. *R. allegheniensis*
      D. Achene beak minute, although curved.
        E. Stem glabrous; roots slender and fibrous; basal leaves generally cordate ..... 8. *R. abortivus*
        E. Stem somewhat villous; some roots fusiform-thickened; basal leaves mostly rounded or cuneate at base ..... 9. *R. micranthus*
    C. Leaves all lobed or divided.
      D. None of the leaves regularly divided to the base; beak of the achene strongly hooked; petals not longer than the calyx ..... 10. *R. recurvatus*
      D. At least the upper leaves divided to the base; beak of the achene not strongly hooked.
        E. Head of fruit oblong or cylindric; flowers 6-8 mm. broad.

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* Denotes those species not yet found in West Virginia.

1 Terrestrial forms of *R. flabellaris* may be sought here.

F. Leaf divisions mostly stalked, their lobes acute; plant hispid-pubescent ..... *11. *R. pennsylvanicus*

F. Leaf divisions not stalked, their lobes obtuse; plant usually glabrous ..... 12. *R. sceleratus*

E. Head of fruit globose; flowers at least 1.5 cm. broad.

F. Leaves palmately 3-7 parted, the usually narrow divisions mostly sessile; inflorescence branched ..... 13. *R. acris*

F. Leaves 3(-5) -divided, at least the terminal division stalked (except in *R. hispidus*).

G. Stem base bulb-like; leaves with lateral divisions sessile, the terminal stalked; calyx reflexed ..... 14. *R. bulbosus*

G. Stem base not bulbous.

H. Achene beak short, somewhat hooked; introduced creeping species mostly of lawns and disturbed areas ..... 15. *R. repens*

H. Achene beak long, at most only slightly curved; native plants; creeping only in *R. septentrionalis*.

I. Leaves pinnately divided, ultimate divisions linear or oblong, usually blunt; often with some roots much thickened ..... *16. *R. fascicularis*

I. Especially the lower leaves palmately divided, divisions wider; roots all uniform, although slightly fleshy.

J. Plants soon developing elongate trailing branches; basal leaves almost with stalked divisions; plants of low ground and stream floodplains ..... 17. *R. septentrionalis*

J. Plant with tufted, erect or ascending stem; lowest basal leaves usually only 3-lobed or with 3 sessile divisions; plants commonly of dry hillsides ..... 18. *R. hispidus*

Three introduced species confined mostly to coastal regions, may, at least eventually, reach this state. *R. ficaria* is characterized by 3 sepals. *R. arvensis* has spiny-tuberculate achenes and leaf-lobes narrow, subacute. *R. parviflorus* has rough papillose achenes, and leaf-lobes broadly oval, obtuse.

1. RANUNCULUS TRICHOPHYLLUS Chaix. in Villars, Hist. Pl. Dauph. i. 335. 1786.

Labrador to Alaska, south to West Virginia, Minnesota, and California.

R. trichophyllus and *R. longirostris* belong to the sub-genus Batrachium (Drew). This sub-genus is sometimes split off as a genus with the same name. The species included in this group are characterized by transversely wrinkled achenes, white petals (with sometimes yellow claw), and aquatic habit.

The subgenus as a whole is somewhat northern and western, West Virginia being near the southern limit of the two species treated here. *R. trichophyllus* is the only one which has been found in the state, although *R. longirostris* is the most common species near our region.

Hardy: Cacapon River near Wardensville, *Core*, August 11, 1932.

2. RANUNCULUS LONGIROSTRIS Gordon. Mem. Soc. Sc. Nancy, 1839, t. 2, fig. 9. 1840.

In quiet waters (calcareous at least in eastern North America) from

western Quebec to Oregon, south to Delaware, Tennessee, Kansas, and Arizona.

3. RANUNCULUS FLABELLARIS Raf. Am. Mo. Mag. ii. no. v. 344. March, 1818.

R. delphinifolius Torr.

Shallow water or mud; Maine to British Columbia, south to New Jersey, in the Mississippi Valley to Louisiana, and in the west to California.

This species, although it has always been placed in *Ranunculus,* has finely dissected leaves like the subgenus Batrachium. However, the divisions are not so filiform, and they have a flat appearance in contrast to the divisions of the two preceding species, which are so fine as to seem cylindrical. Terrestial forms (var. *terrestris* Farwell) occur in which the leaves are simply divided into linear or cuneate segments.

There are no records of the discovery of this species in the State, but if found, its aquatic habitat, decumbent habit, and bracted, racemose inflorescense should leave it easily distinguishable from other species of the State.

4. RANUNCULUS PUSILLUS Poir. in Lam. Encyc. Meth. 6:99. 1804.

Ditches and marshy ground: New York to the Gulf of Mexico, north in the Mississippi Valley system to Missouri and West Virginia.

This is evidently a coastal and Mississippi Valley species which has come up the Ohio River as far as Cabell County. It is easily distinguishable from *R. ambigens,* but not so easily from *R. laxicaulis,* which seems to occupy an intermediate position between the two, with respect to size and leaf characters. *R. ambigens* is best distinguished by its large size and beaked achenes, *R. laxicaulis* from *R. pusillus* by its larger petals.

Wayne: near Fort Gay, *Isabelle Lycan,* April, 1932.

5. RANUNCULUS LAXICAULIS (T. & G.) Darby Bot. S. Sts. 204. 1855.

[*R. oblongifolius* (of authors generally, not Ell.—acc. to Fernald '39.)].

Marshy ground and ditches; Delaware and Maryland to the Gulf of Mexico, north in the Mississippi Valley to Missouri and Indiana.

See discussion under *R. pusillus* for distinguishing characteristics.

6. RANUNCULUS AMBIGENS Wats. Bibl. Ind. N. Amer. Bot. 1:16. Mar., 1878.

R. laxicaulis (T. & G.) Darby.

Wet places; Maine to Minnesota, south to Virginia, Tennessee, and Louisiana.

See discussion under *R. pusillus* for distinguishing characteristics.

Harrison: near Clarksburg, *Judy*, summer, 1934; Nicholas: Muddlety Cr., Copeland, *W. V. U. Biological Expedition*, July 3, 1939; Pendleton: Judy Gap, *Core*, July 22, 1931; Randolph: Beverly, *Millspaugh*, July 7, 1890; Upshur: swampy spot, *Millspaugh*, July 7, 1890; Wayne: Prichard Pond, *Plymale*, no. 478.

7. RANUNCULUS ALLEGHENIENSIS Britt. Bull. Torrey Club 22:224. 1895.

Rich woods and rocky calcareous or basic slopes, less often in meadows or along roadsides, rather local; Massachusetts to Ohio, south to North Carolina and Tennessee.

The comparatively large, recurved beak of the achene (about one-half the achene length) is the only character which readily sets this species off from the two following. However its glaucous condition and comparative robustness with more branching serve to distinguish it in the field.

Hampshire: Springfield, *S. A. B. C. Foray*, May 3, 1940: Marion: along Hickman's Run, Fairmont, *Myers*, April 18, 1938; Monongalia; Cheat, *Spangler*, May 14, 1915; Uffington, *Core and Dean;* Canyon, *Mr. and Mrs. Davis*, no. 2859; Booth's Creek, *Sharp*, May 15, 1931.

8. RANUNCULUS ABORTIVUS L. Sp. Pl. 551. 1753.

Rich woods; Labrador to British Columbia and southern Alaska, south to Florida, eastern Texas, and southern Colorado.

The key characters will satisfactorily separate this and the following species, although additional identifying characteristics may be the usually hairy receptacle of *R. abortivus* as compared with the smooth one of *R. micranthus*. The receptacle itself is rougher in the former. Basal leaves of *R. abortivus* usually have more teeth than do the basal leaves of *R. micranthus*. This however is not a result of teeth size, but of the larger circumference of the leaves of the former, resulting from the larger and more heart-shaped leaves. (See Fassett '42 & Fernald '38).

Berkeley: Rock Cliff Drive, *Shreve*, May 2, 1937; Cabell: Milton, *Williams*, no. 394; 16th St. road near Fourpole Creek, *Smithson*, April 14, 1936; Calhoun: Pink, *Harris*, April 15, 1933; Big Springs, *Harris*, May 27, 1933; Hampshire: Hanging Rock, *Frye*, no. 503; Kanawha: Clendenin, *Strickland*, May 26, 1933; Gilligans Hill, *Greenlee*, April 24, 1935; Lincoln: near West Hamlin, *Thacker*, May, 1940; Monongalia: "Maplehurst," "*Big Three*," no. 116; Morgantown, *Ammons*, May 14, 1924; Dellslow, *Rumsey*, May 8, 1896; Seneca, *Shaid*, April 8, 1922; one mile east of Morgantown, *Myers*, May 9, 1937; Dent's Run, *Ammons*, April 23, 1925; Ohio: growing in deep rich woods on Nichol's Hill, Wheeling, *Bartholomew*, 0179; Preston: Three Forks Creek, *Mr. and Mrs. Davis*, no. 3955; Raleigh: Hinton, *Tosh*, April 27, 1940; Ritchie: Cairo, *Goodwin*, April, 1930; Summers: near Hinton, Boone, no. 100; Wayne: Lavalette, *Plymale*, no. 228; Wirt: one-half mile up Little Kanawha River from mouth of Reedy Creek, *Bartholomew*, no. 1938-637; near Owensport, *Bartholomew*, April 15, 1933.

9. RANUNCULUS MICRANTHUS Nutt. ex. Torr. & Gray. Fl. N. Am. 1:18. 1838.

Woodlands; Massachusetts to South Dakota, south to Georgia and Arkansas.

See discussion of identifying characteristics under *R. abortivus*.

Brooke: *Oglebay Plant Club*, May 2, 1937; Hampshire: Okonoko, *Frye*, May 10, 1935; Monongalia: half mile below Morgantown, *Myers*, April 18, 1937; below Seneca, Morgantown, *Riggle*, March 29, 1921; Morgantown, *Spangler*, April 24, 1912; Seneca, *Myers*, April 13, 1938; Ohio: Wheeling, *Quantz*, no. 218; The Beeches, Oglebay Park, *Brooks*, April 11, 1929; Waddington, along nature trail, *Strausbaugh*, April 13, 1929.

10. RANUNCULUS RECURVATUS Poir. in Lam. Encyc. Meth. 6:125. 1804.

Woods and thickets; Newfoundland to Minnesota, south to Georgia, Louisiana, and Oklahoma.

This in one of the most distinctive and easily recognized members of the genus. Vegetative growth, flowers, and fruits all display identifying characteristics. The plant, especially when young, has a scape-like appearance, with leaves chiefly at the base and at the top of the stem.

Calhoun: Grantsville, *Harris*, May 8, 1933; Fayette: Nuttallburg, *Nuttall*, 1890; Hampshire: Okonoko, *Frye*, May 22, 1935; Kanawha: Chappell Hollow, *Greenlee*, May 11, 1940; Lincoln: near West Hamlin, *Thacker*, May, 1940; Hamlin, *Harris*, May 28, 1933; Monongalia: Decker's Creek, *Nolan*, spring, 1909; Monongahela River, Little Falls, *Millspaugh*, no. 120; Falling Run, *Millspaugh*, no. 90; Dent's Run, *Stevens*, May 19, 1924; Doll's Run, *Core*, May 20, 1934; Hilderbrand, *Ammons*, May 2, 1925; Ohio: Oglebay Park, *Strausbaugh*, May 18, 1929; six miles up Middle Wheeling Creek, *Bartholomew*, no. 01937-370; Raleigh: foot of Batoff Mt., *Tosh*, no. 124; Wayne: ravine near Hubard's Branch, *Gilbert, Williams, and Pierle*, no. 447; near Wayne on Route 52, *Smithson*, May 3, 1936; Buffalo Creek, *Plymale*, June 15, 1937; Wetzel: Wolf Run, *Haught*, no. 1006; mouth of Wolf Run just north of Littleton, *Haught*, no. 467; one and one-half mile west of Littleton, *Haught*, no. 526; Wirt: near Owensport, *Bartholomew*, June 6, 1933.

11. RANUNCULUS PENNSYLVANICUS L. f. Suppl. 272. 1781.

Wet, open places; Newfoundland to at least New Jersey and westward, in the west from southern Alaska to Arizona; also in China.

This rather robust and bristly plant has not been found in West Virginia, but, although somewhat northern in distribution, may eventually be found in suitable locations at the higher altitudes.

12. RANUNCULUS SCELERATUS L. Sp. Pl. 551. 1753.

Borders of lakes and marsh land; native or naturalized from Quebec and Maine to North Dakota, south to Florida and Louisiana; also in Washington and Oregon.

This species is not easily confused with others of the group, if the key characters are sought out. Its habitat is not common with many of our buttercups, and its hollow stem and cylindrical fruiting head with the small beakless achenes (about 1 mm. long) are distinctive.

Hardy: Moorefield, *Millspaugh*, May 27, 1892; Jackson: Cottageville, Mill Creek, *W. V. U. Biological Expedition*, June 30, 1931.

13. RANUNCULUS ACRIS L. Sp. Pl. 554. 1753.

Pastures, meadows and roadsides. This tall, weedy plant has become naturalized from Europe, and is widely distributed in northern United States and southern Canada. In England the name Buttercups is chiefly applied to this and the two following species.

Greenbrier: near Camp Alvon, *Smithson*, July 18, 1938; Harrison: near Clarksburg, *Judy*, summer, 1934; Kanawha: Clendenin, *Strickland*, May 26, 1933; Queen Shoals, *Randolph*, no. 190; Marion: *Hale*, Monongalia: Star City, *Spangler*, June 24, 1924; southeast of Morgantown, *Sheldon*, no. 1444; Nicholas: Camp Woodbine, *Fox*, June 22, 1940; Raleigh: "common all over county," *Tosh*, May 24, 1940; Randolph: three miles east of Harman, *Core*, July 16, 1937; Pickens, *Perine*, spring, 1938; Tucker: Thomas, *Green*, July 13, 1928.

14. RANUNCULUS BULBOSUS L. Sp. Pl. 554. 1753.

Fields and roadsides. This is another naturalized species, but it is not as widespread as the preceding species, and does not commonly form as large a colony.

Fayette: Clifftop, *West*, May 30, 1937; Greenbrier: *Tyree*, May 29, 1899; Monongalia; mile east of Morgantown, *Myers*, May 9, 1937; Falling Run near Morgantown, *Palmer*, May 17, 1923; Morgantown, *Ammons*, May, 1924; Decker's Creek, *Nolan*, spring, 1909; Morgantown, *Stevens*, May 14, 1924; Observatory Hill, Morgantown, *Beard*, May 17, 1923.

15. RANUNCULUS REPENS L. Sp. Pl. 554. 1753.

Meadows, marsh borders, and lawns. This is another naturalized species, best distinguished by its creeping, weedy habit. A double-flowered form (*R. repens* L. var. *pleniflorus* Fern.) is cultivated and has been found escaped. It differs also in its usually larger leaves, with leaflets broader and rounded at the base.

Harrison: Shinnston, *Martin*, no. 244; Mercer: Athens, *W. V. U. Botanical Expedition*, July 13, 1928; opposite 4-H Grounds, Princeton, *W. V. U. Biological Expedition*, June 26, 1940.

16. RANUNCULUS FASCICULARIS Muhl. ex Bigel Fl. Bost. Ed. 1:137. 1814.

Rather dry situations; southwestern New England to Minnesota, south to Tennessee and Oklahoma.

This species has long been reported from the state, but no authentic specimens have been seen. However, West Virginia is in the range of the species and it should eventually be discovered.

The best distinguishing characteristics are found in the leaves, which appear pinnately divided, with narrow, obtuse ultimate segments, and in the roots, many of which may be much thickened. This last characteristic is not found in all specimens, however, and the absence of them is no assurance that the specimen is not this species.

17. RANUNCULUS SEPTENTRIONALIS Poir. in Lam. Encyc. Meth. 6:125. 1804.

Banks and flood plains of streams, and marshy ground; Labrador to James Bay and South Dakota, south to Georgia, Tennessee, and Texas.

This and the following species admittedly sometimes give the author trouble, especially in herbarium sheets. If one is able to see the full life history of these two species, it is believed that little trouble will be found. The outstanding difference is the development of the trailing stems in *R. septentrionalis*. They do not begin to develop, however, until about flowering time. From then on they grow rapidly, and by early summer have rooted at the tips, sending up several leaves. Such trailing stems are entirely lacking in *R. hispidus*. A plant with many, small, 3-parted basal leaves also stamps it as the latter species. All plants of this species may not be thus, however. Any plant growing on dry hillsides would certainly be *R. hispidus*, but it may be found in moister places. *R. septentrionalis*, on the other hand, is common on the banks and flood plains of streams and in swamps.

R. septentrionalis can be smooth, appressed pubescent, or pilose-hispid. However, it does not have the silky, appressed pubescence of many specimens of *R. hispidus*. Another difference, called to my attention by as yet unpublished material from Prof. Fernald, is the usual presence in *R. septentrionalis* of conspicuous stipules which are rounded at the summit. Stipules of *R. hispidus* are inconspicuous.

No attempt has been made to separate systematically the described varieties of both species.

Calhoun: Brooksville, *Harris*, May 13, 1933; Fayette: Nuttallburg, *Nuttall*, no. 118, 1890; Monongalia: Dent's Run, *Stevens*, May 19, 1924; Little Falls, *Millspaugh*, April 30, 1890; Davis's Garden, Morgantown, (plants from Dunkard Creek), *Mr. and Mrs. Davis*, no. 3945; Pendleton: Franklin, *Mr. and Mrs. Davis*, no. 3944; Preston: Arthurdale, in swamp, *Mr. and Mrs. Davis*, no. 3941; Summers: along edge of New River, *Tosh*, April 16, 1939; Brooks, *Boone*, no. 414.

18. RANUNCULUS HISPIDUS Michx. Fl. Bor. Amer. 1:321. 1803.

Commonly in dry woods, Vermont to North Dakota, south to Georgia and Arkansas.

See discussion under *R. septentrionalis* for distinguishing characteristics.

Barbour: Alderson-Broaddus College region, *Williamson and Arnold*, May 20, 1938; Berkeley: Rock Cliff Drive, *Shreve*, May 2, 1937; Cabell: Milton, *Williams*, no. 411; Calhoun: Pink, *Harris*, April 19, 1933; Big Springs, *Harris*, July 13, 1934; Freed, *Harris*, May 28, 1933; Dodrill, *Harris*, April 22, 1933; Grantsville, *Harris*, April 13, 1933; Hampshire: Hanging Rock, *Frye*, May 18, 1933; Ice Mountain, *Frye*, April 30, 1939; Kanawha: Gilligan's Hill, *Greenlee*, April 20, 1935; Clendenin, *Strickland*, May 25, 1933; Chappell Hollow, *Greenlee*, May 11, 1940; Monongalia: near State Farm, Morgantown, *Benson*, April 29, 1925; Decker's Creek, *Nolan*, spring, 1909; Morgantown, *Garcia*, May 20, 1924; Star City Road, *McDaniel*, May 12, 1923; Preston: Dillons Creek, *Zinn*, May 3, 1936; Raleigh: Glen White, *Tosh*, no. 227; Summers: Keatley Spring, *Boone*, no. 413; Hinton Mt., *Tosh*, April 16, 1939; Tyler: near Shirley, *Brooks and Margolin*, May 8, 1937; Wayne: near Fort Gay, *Lycan*, no. 37; Wirt: near Owensport, *Bartholomew*, April 15, 1933.

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Wood as a Substratum for Perennial Plants in the Southeast

Paul C. Lemon

The forests of the Coastal Plain, with their high rainfall and long growing seasons, provide many unique places where seeds may find a favorable habitat in which to germinate. Seed plants ordinarily terrestrial have been found rooting in fallen logs, sawed stumps, natural stumps or "snags" left by fire, trees killed by lightning, dead tops or "stag-heads," dead cypress knees, and in chopped turpentine "boxes." Numerous interesting photographs and detailed observations have been obltained during the last two years' field experience in the Coastal Plain of Georgia. At least nine species of perennial herbs, ten shrubs, and five kinds of trees have been observed to have started growing in dead wood. A list of these "wood-dwelling" perennials is given in Table 1, together with an indication as to their reproductive success and commonness in this habitat. Further observation would doubtless add other species to the list. No cryptogams are included. A few perennials found growing in wood in certain parts of North Carolina are reported separately in Table 2. Various seed plants have been observed growing on wood in northern Florida also.

At least half of these species finally reached the fruiting stage. By the time these plants are large enough to reproduce, they have root systems well established in the decayed wood in which they are growing, and those growing in low stumps or logs will have extended their roots through the rotten wood into the mineral soil beneath.

In one example, however, a gallberry bush (*Ilex glabra*) was found growing in some dead wood high in the top of a living longleaf pine. The roots of this plant penetrated the dead wood in an irregular cavity left by the breaking away of a large limb. Thus the bush was growing and fruiting 50 feet above the ground. Other shrubs have been seen in the tops of dead trunks 30 or 40 feet tall. In Figure 1 the natural stump was about seven feet tall. A slash pine tree about 18 inches tall was found growing in a floating log in a pond, obviously without roots in mineral soil.

Stumps of any kind frequently harbor these "terrestrials." Figures 2 and 3 are photographs of sawed stumps 3.0 and 2.5 feet tall, respectively. Figure 4 is probably a natural stump although this could not be ascertained with certainty. Figure 5 is doubtless a natural stump.

Dead knees of pond bald cypress (*Taxodium ascendens* Brongniart) sometimes provide a temporary substratum for land plants in the swamps and, of course, the live knees frequently are superficially inhabited by the more simple and primitive members of the plant kingdom. Where these dead knees occur surrounded by water there are no other places for a land plant to grow.

Turpentine "boxes" provide another type of niche in which seed plants

TABLE 1.—Species found growing in dead wood, and their approximate degree of success or commonness as indicated by normal fruits and frequency of occurrence, in the Middle and Lower Coastal Plains of southern Georgia.

Species	Established	Reproducing	Very Common
Herbs			
Andropogon virginicus L.		×	×
Aristida virgata Trin.	×		
Carex spp.		×	
Chrysopsis graminifolia (Michx.) Nutt.	×		
Hieracium gronovi L.		×	
Panicum spp.		×	
Paspalum laeve Michx.		×	
Paspalum setaceum Michx.		×	
Rhexia virginica L.		×	
Shrubs and Lianas			
Aronia arbutifolia (L.) Ell.		×	
Baccharis halimifolia L.	×		
Gaylussacia dumosa (Andr.) T. & G.	×		×
Ilex glabra (L.) A. Gray		×	×
I. cassine var. *myrtifolia* (Walt.) Sarg.		×	
Lyonia lucida C. Koch		×	
**Pieris phillyreifolia* (Hook.) DC.		×	
Rhus copallina L.	×		
Rubus cuneifolius Pursh.	×		
Smilax laurifolia L.	×		
Vaccinium myrsinites Lam.		×	×
Trees			
Acer rubrum L.	×		
Pinus caribaea Morelet		×	×
Pinus palustris Miller	×		
Pinus rigida var. *serotina* (Michx.) Loud.	×		
Quercus nigra L.	×		

* It is possible that this species may germinate in the soil and later climb up through rotten wood or bark.

TABLE 2.—Species observed growing in dead wood in North Carolina.

Species	Established	Reproducing
Coastal Plain		
Aronia prunifolia (Marshall) Rehder	×	
Rubus trivialis Michx.		×
Pinus rigida var. *serotina* (Michx.) Loud.	×	
Great Smoky Mountains		
Andropogon virginicus L.		×
Rubus spp.	×	
Pinus rigida Miller	×	

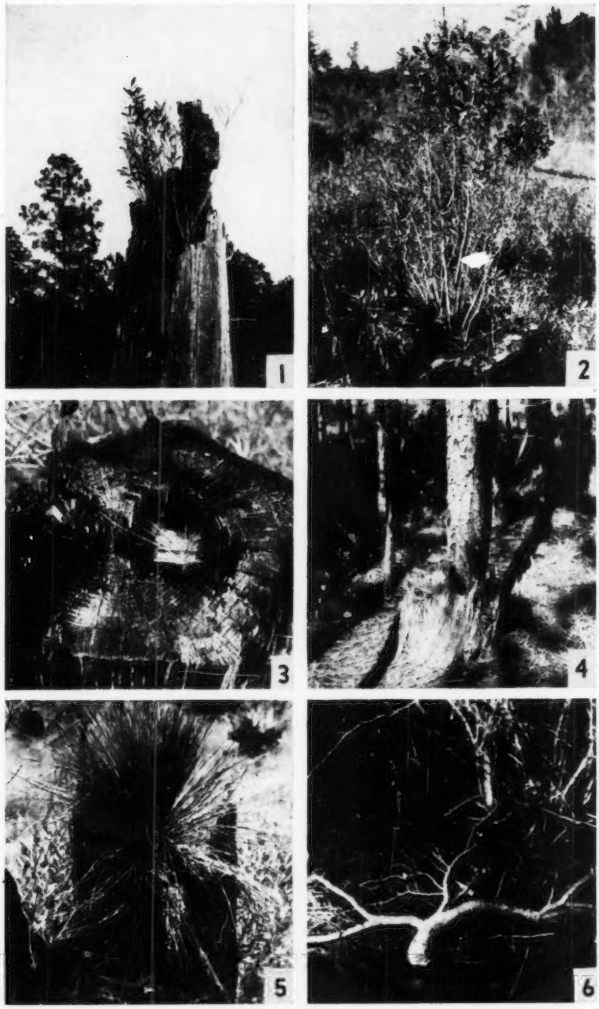
sometimes grow. Up until 1910 to 1915 many naval stores operators chopped a cavity or "box" in the trunk, which method has since been improved upon by the use of a manufactured metal or clay cup for catching the gum. Several herbs, shrubs, and trees have been found in these old "boxes," both in dead stumps and in live pines. In the latter case there is considerable dead wood beneath and around the old box and in the turpentine face above it as a result of the harsh treatment attending that method of turpentining.

Another similar microhabitat, perhaps even more frequently populated by higher plants, is the mound of woody litter that often forms at the base of a large swamp tree. This miniature island is built up by the accumulation of the bark, twigs and other woody debris that falls at the base of the trunk. At the same time the major radial roots expand by their growth and tend to lift this material somewhat. Herbs, shrubs, and trees often start in this aerated hump of decayed woody refuse.

The behavior of *Pieris phillyreifolia* (Table 1) is quite unlike that of the other shrubs in that this species starts growth on the ground and then is able to ascend trees by creeping under their bark. These creeping stems are very much flattened for they are tightly pressed underneath the bark, and they occasionally put out branches with leaves and flowers that appear to be growing directly out of the trunk. It would be necessary to find a young germinating specimen in order to be certain that it can actually germinate in dead wood. Although some of the specimens seen in the field on stumps and dead cypress knees look as though they had originated in a wood substratum, a positive check has not yet been possible. At any rate, the behavior of *P. phillyreifolia*, the only ericaceous "vine" in the Southeast, is certainly different from that of the usual liana. Harper (1928) and Small (1933) have also observed the peculiar habit of this plant.

Growth in these woody substrates is approximately normal, although it is somewhat less rapid due to the unfavorableness of the habitat. Yet the southeastern soils are relatively low in nutrients, and it may be that the native plants are fairly tolerant of the low mineral content of decayed wood and can exist on a scant supply. Reference to Table 1 will reveal that half of the species listed are able to reach the stage of reproduction. The development of the shrubs seems to progress at a rate close to normal, but the trees will fail or be greatly retarded because they make much greater demands upon the substrate than do herbs and shrubs. A gallberry bush one year old was 1.5 feet tall. Probably tree species are severely stunted unless they are able to put their roots into a large volume of suitable soil within two or three years, and this is not possible unless the wood is very rotten and the tree germinates not too far above the ground surface. While small slash pine (*Pinus caribaea*) specimens are frequently encountered, it is very seldom that one finds a tree large enough to bear cones. Of course, in many cases this is due to the fact that the rotting of the original stump or log is so advanced when the seedling first becomes established that the log disintegrates and disappears before time enough passes to allow a pine tree to mature.

The use of dead wood by swamp black tupelo roots (*Nyssa sylvatica* var.



Figs. 1-6. Wood substrates. 1. Fruiting *Ilex glabra* in a natural stump. 2. Very large fruiting *Ilex glabra* in a sawed stump 3 feet tall. 3. Slash pine seedling in a sawed stump 2.5 feet tall. 4. Slash pine 8 inches d.b.h., growing in an old stump. 5. Longleaf pine several years old, growing in a natural stump. 6. Rotten log with the bark and outer wood removed to show a swamp black tupelo root ramifying through the wood.

biflora Sarg.) is unique in that whereas the tupelo does not start in wood, its roots very frequently enter and permeate a nearby fallen log or rotten stump. It is not uncommon to find a tupelo root as much as an inch in diameter entering a soft rotten log. As shown in Figure 6, the roots ramify and subdivide until they have occupied nearly every cubic inch of the log. On one occasion some small rootlets were noticed in a soft, rotten pine log at a place where some of the bark had fallen away. When this log was torn apart with the hands, a large main root 1.25 inches in diameter was found extending longitudinally through the trunk. The root had come up from directly beneath, traversed the log for six feet, and re-entered the ground just before reaching the end of the log.

Tupelo trees that send roots into decayed logs and stumps in this manner are to be found growing in wet swamps where soil aeration is very poor. These roots are themselves very porous and light in weight, suggesting the aerenchyma of many pond and marsh plants. The density of a large "wood-inhabiting" root was found to be .152. This is about one-third the density of a section of trunk wood of the same species taken above the high water mark, and approximately the same density as balsa wood from tropical America.* These roots are readily identified in the field by their sponginess and characteristic way of breaking by fracture at right angles to the root rather than splintering. Some roots have been found growing upward in an old stump to a height of over two or three feet above the ground or water level. This occurs so frequently that almost every thoroughly decayed log lying within 20 feet or less of a swamp black tupelo tree is inhabited by these roots.

The ecological significance of wood as a substratum for higher plants is not totally clear but nevertheless examples of plants apparently growing successfully in wood are too numerous to be considered unimportant accidents. In the particular square mile investigated there were 30 or 40 slash pine trees and probably over a hundred shrubs growing very well in wood. The possibility of a similar phenomenon in the West has been shown by Fisher (1935) who studied the germination of nine western tree species in various disturbed and natural substrates, including rotten wood. He analyzed the data in various ways but preferred to rate the surface materials for their efficiency as germination media according to the germination percentages of the individual species. Then, by adding the scores of the nine species, it was found that ash rated first, rotten wood second, bared mineral soil third, and the various forms of duff next in order. When he added all the germination data together without regard to species, he found that rotten wood rated first, ash next, and the various others followed in their turns. Fisher concedes that there are certain objections to this manner of analysis. His study was not extended to include seedling survival as was that of Haig, Davis and Weidman (1941) who followed the seedlings through under natural conditions in the western white pine type. They found that both germination and survival were highest on mineral soil. The germination percentage was better on rotten wood than on duff but this

* The densities of *Nyssa* wood were determined from samples collected near Alapaha, Georgia; the balsa density used here is the air dry density as given by Hodgman and Holmes (1941).

advantage was counter-balanced by higher seedling mortality on the former, due to the drying out of the medium. Even so, the four hardier tree species had 35 per cent survival of seedlings on rotten wood after five years. The present investigation does not present quantitative data on germination and survival on wood but does give numerous examples of successful maturation and reproduction of a number of woody species which does, of course, imply satisfactory germination and growth.

In regard to succession, these curious woody habitats, under some circumstances, might act as refugia for surviving severe fire. Shrubs growing 20 feet or more off the ground might escape severe fires and live to furnish parent stock for replenishment. In a similar way, upland plants may grow on dead wood in the midst of the watery habitat of a swamp and in that way escape severe fires. In the swamps that are gradually being filled, the "advance guard" or initial invaders might be wood-dwelling terrestrials. Numerous examples of these ecological rôles have been observed, although there has been no opportunity to test their effectiveness over a long period of time.

SUMMARY

At least 25 species of native perennials (normally terrestrial) have been found growing in decayed wood in the Coastal Plain of Georgia, at least half of them reaching the fruiting stage. Six perennials were observed growing in wood in North Carolina, and some were seen in northern Florida also.

These land plants grow on woody substrates such as natural or man-made stumps or "snags," fallen trunks, dead tops of live trees or "stag-heads," dead cypress knees, and chopped turpentine "boxes." Roots of *Nyssa sylvatica* var. *biflora* frequently enter decayed wood in swamps, presumably because the logs and stumps are better aerated than the soil.

The fact that these terrestrials are growing in the tops of dead trunks or on stumps and logs in swamps may have importance in providing a habitat where plants escape fires and produce seed for replenishing their stand on severely burned areas. They may also be the pioneer invaders in swamps that are being gradually filled by soil.

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The Algae of Crystal Lake, Cleveland County, Oklahoma[1]

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Introduction

Little was known about algae of Oklahoma until 1929 as no systematic work had been done and no records had been published. In that year Taft started an investigation on the extent of the algal flora of the state. His first published reports were on the Desmidiaceae (1931, 1934, 1937) the Oedogoniaceae (1935), and the Vaucheriaceae (1937). A paper on the Zygnemataceae by Transeau, Tiffany, Taft, and Li (1934) was a report of new species only. Leake (1939) reported motile cells of *Basicladia crassa* Hoffman and Tilden. Additional species were listed by Taft (1940). The total number of recorded algae of Oklahoma preceding the present investigation was 458 species, varieties, and forms.

In his paper on the Chlorophyceae and Heterophyceae of Oklahoma, Taft (1935) discussed the effects of topography, climate, and geology upon the distribution of the families of algae throughout the state. A study of Crystal Lake, the site of the present investigation, was the subject of a study of ecological relations with respect to Protozoa by Bragg (Unpublished paper).

The present investigation was designed to add to the taxonomic list of algae of the state and to contribute data on the environmental factors operative upon the algal flora of Crystal Lake, a small artificial lake on the prairies near Norman, Oklahoma.

Crystal Lake was constructed in 1929. It is privately owned and has been used for swimming, boating, fishing and duckhunting. It is on U.S. Highway 77 about one mile north of the city of Norman, where the prairie breaks into a watercourse. To make it, a dam was thrown across the valley of an intermittent stream leading toward a branch of Little River. The soil is red clay weathered from Hennessey Shale of late Permian formation. Small concretions of magnesium and calcium carbonates, in a zone near the top of this clay, form gravel along the southern and northwestern margins of the lake.

The area normally covered by the lake is approximately twenty-four acres. The average depth is five feet, the maximum depth is thirty-two feet. The vegetation of the region in which it is located is mixed-grass prairie type. The land immediately surrounding the body of water had been overgrazed within five years before the beginning of this investigation. During the progress of the work, however, pasturing was not heavy enough to cause turbidity of the water from erosional runoff.

1 Summary of a thesis for the Ph.D. degree, University of Oklahoma, 1944.

The lake has no inlets, the water supply being furnished by the drainage basin in which the lake lies. Gullying of the area has been very moderate due to the gentleness of the slope and the adequate ground cover. However, a cow path along the fence at the south end caused the initial bare area and vulnerability to erosion there evident.

The entire two-mile shore line is quite irregular as shown in the outline map. Five arms of shallow water form narrow bays. Along some portions of the lake the slope of the bottom is gradual from the water line. The resultant productive zone of shallow water may extend far out into the lake, in some cases, the full distance across. Other portions of the shore have steep banks which slope abruptly so that there is deep water a foot or a few feet from shore. This irregularity of outline and the variation of depth close to the margin furnish a great variety of conditions with respect to exposure and wave action. Consequently the habitats are varied.

A few willows grow along the banks. The cattails, *Typha truxillensis* L., and *T. latifolia* L., flourish along the east margin except in seasons of extreme drought. At such times they are apt further to be injured by the practice of burning off the land. During dry periods recession of the water leaves a margin from two to twenty feet wide along most of the shore line. The plants which quickly gain foothold in these areas are chiefly *Polygonum Hydropiper* L., *Eclipta alba* (L.) Hassk., *Cyperus strigosus* L., *Eleocharis quadrangulata* (Michx.) R. & S., *E. acicularis* (L.) R. & S., and *Xanthium echinatum* Murr.

The hydrophytes of the higher groups of plants are mainly *Potamogeton amplifolius* Tuckerm., *P. foliosus* var. *macellus* Fernald, *Sagittaria latifolia* Willd., and *Marsilea mucronata* A. Br. Of these, *Potamogeton amplifolius* is a dominant species, sharing its dominance with two species of the alga *Chara*. During periods of normal rainfall *Potamogeton amplifolius* lines the bays and is found along other margins which are protected from violent wave action. Just outside the shade of its broad floating leaves is a zone of *Chara*. At the east end of the lake, a patch of the white water lily, *Castalia tuberose* (Paine) Greene, occupies about three square yards of space. This plant was probably placed here at some time in the past by the owner of the lake.

The drainage area is mixed-grass prairie. The dominant grasses are *Andropogon saccharoides* Swartz., *A. scoparius* Michx., *Bouteloua gracilis* (H.B.K.) Lag., *B. hirsuta* Lag., *B. curtipendula* (Michx.) Torr,, *Aristida purpurea* Nutt., and *Buchloe dactyloides* (Nutt.) Engelm. In the sections disturbed by overgrazing or burning there are fasciations of the grasses, *Bouteloua, Aristida,* and *Buchloe,* and *Gutierrezia dracunculoides* (DC.) Blake, the broomweed.

The prevernal aspect of this drainage area from the middle of March to the last of April, first presents *Erythronium mesochoreum* Knerr. and *Nothoscordum bivalve* (L.) Britton. There soon follow *Houstonia minima* Beck., *Allium mutabile* Michx., *Claytonia virginica* L., *Lithospermum angustifolium* Michx., *Anemone caroliniana* Walt, and *Plantago virginica* L. A late prevernal subdominant is *Sisyrinchium Bushii* Bicknell.

During the vernal season various species of *Andropogon* begin to assume dominance. At this time there are also *Baptisia autralis* (L.) R. Br., *Psoralea tenuiflora* Pursh., *Oenothera serrulata* Nutt., *Apocynum cannabinum* L., and *Erigeron ramosus* (Walt.) BSP. The vernal season extends until the first of June.

The estival season, which lasts until the end of July, brings *Callirhoe involucrata* (T. & G.) Gray, *Amorpha canescens* Pursh., *Cassia nictitans* L., *Euphorbia maculata* L., *E. marginata* Pursh., *Acerates auriculata* Engelm., *A. viridiflora* Ell., *Gaillardia pulchella* Foug., *Specularia leptocarpa* (Nutt.) Gray, and *Gutierrezia dracunculoides*.

The serotinal season begins early in September. During this time several species of *Solidago* as well as *Ambrosia artemisiifolia* L. are in flower.

Cooler weather of the autumnal season begins toward the latter part of September. Many of the estival forms persist throughout this season until frost. Among them are *Gaillardia pulchella, Cassia nictitans, Euphorbia marginata,* and *Gutierrezia dracunculoides*. Flowering times of the *Solidagos* and *Ambrosia artemisiifolia* are prolonged also.

In addition to the dominant and subdominant grasses already mentioned, the following have been identified during the autumnal period. *Echinochloa crusgalli* (L.) Beauv., *Panicum virgatum* L., *Sorghastrum nutans* (L.) Nash, *Sporobolus cryptandrus* (Torr.) Gray, *S. asper* (Michx.) Kunth, *Digitaria sanguinalis* (L.) Scop., *Eragrostis reptans* (Michx.) Nees, *E. diffusa* Buckl., *Paspalum ciliatifolium* Michx., and *Setaria lutescens* (Weigel.) F. T. Hubb. Other plants found during the autumn include: *Acnida tamariscina* (Nutt.) Wood, *Liatris punctata* Hook., *Aster ericoides* L., *A. exilis* Ell., *Gerardia heterophylla* Nutt., *Echinodorus tenellus* (Martius) Buchenau, *Helianthus Maximiliani* Shrad., *H. annuus* L., *Salvia azurea* var. *grandiflora* Benth., *Erigeron canadensis* L., *Gaura biennis* L., *Xanthium echinatum* Murr., *Picris hieracloides* L., *Diodia teres* Walt., and *Conobea multifida* (Michx.) Benth.

Birds observed at Crystal Lake include killdeer, snipe, herons, bitterns, meadow larks, red-winged and yellow-shouldered blackbirds, and sometimes gulls. During periods of migration hundreds of ducks, coots, and other waterfowls visit the lake. Of the aquatic animal life Bragg records:

> Sunfishes and bass are numerous in the lake, but minnows are rare. Turtles and frogs of several species abound. . . . Of the smaller animals, rotifers, nematodes, oligochaetes, Gastrotrichia, snails, small Crustacea, and aquatic insects are abundant at all times. Mussels are rare. *Hydra americana* and *Planaria* sp. are abundant at certain seasons and the former was often taken in plankton collections.[2]

Collecting Sites

In October 1938, twelve stations (see Map) were selected for observation. The stations were chosen to represent all types of habitats found at the lake.

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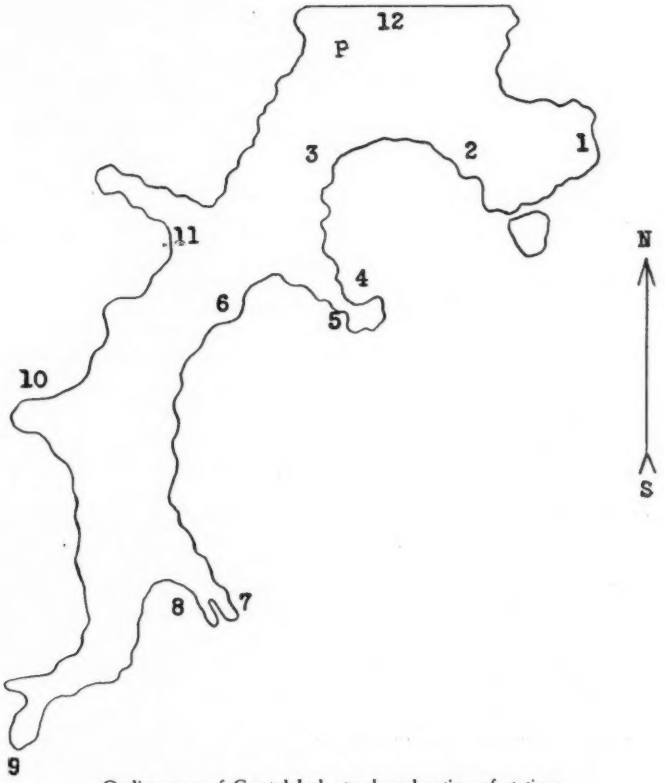
2 Arthur N. Bragg, "An Ecological Study of the Protozoa of Crystal Lake, Norman, Oklahoma." (an unpublished paper, 1935).

Station 1 is located on the east side of the lake at the base of an embankment made of rocks and dirt. It is shallow, with a muddy bottom. During periods of low water a dense mat of *Chara* and *Potamogeton* develops. During periods of high water the rocks of the embankment become covered with attached filamentous algae.

Station 2, on the opposite side of a small bay from Station 1, has a northeast exposure. It is a station extremely rich in both spermatophytes and algae. *Potamogeton, Chara,* and "blanket" algae occur in abundance. Off shore in deeper water is the patch of white water lilies mentioned above.

Station 3 is located on the southeast shore of a rounded peninsula. It is a typical pond-shore habitat with shallow muddy bottom extending about fifty feet into the lake. Its shore slopes gently from a willow thicket to the water



Outline map of Crystal Lake to show location of stations

line. In extremely wet seasons the water line rises to the edge of the thicket. Wave action at this station is severe, causing the attached algae to be limited to spots protected from the greatest disturbance. Neither *Potamogeton* nor *Chara* is abundant here except at certain periods of continuous quiet weather.

Station 4 is on the east side of an arm of shallow water, entirely protected from the violence of the wave action in the main body of the lake. Like Station 2 it contains a great variety of algal forms.

Station 5 is on the west side of the same shallow arm of water directly opposite Station 4. It is different from Station 4 only in position. By April, 1939, it became dry, but heavy rains during 1941 filled it again.

Station 6, like Station 3, has a southeast shore, but differs from it in having a sharp drop to deep water. Only a small amount of *Chara* and *Potamogeton* grow here and the filamentous forms of algae appear only sporadically.

Station 7 is off the southeast shore of another long bay, and is also protected from the wave action of the lake. It differs from Station 4 and 5 in having a steeper bank, though the water is shallow and the muddy character of the shore line is modified by the gravelly deposits of magnesium and calcium carbonates previously mentioned.

Station 8 is close to Station 7, but on the south end of a deep gully completely sheltered on the southwest and north sides. By the end of March, 1939, it, like Station 5, became dry and was refilled by the rains of 1941. The chief interest of this station lies in the great quantity of *Spirogyra* found here. The station also proved interesting because of the consistently high alkalinity of the water.

Station 9, chosen because of its position at the south end of the lake, is another shallow water station. The water is turbid because of the continual churning of the soft mud bottom by the feet of the cattle which come here to drink. Algal growth at this station is luxuriant. Because of the decay of masses of algae and the droppings of the cattle, the water contains much organic matter.

Station 10 is on the north shore. It is sheltered from the north wind by a high clay bank, but is exposed to the south. A shelf covered with silt extends two to three feet from the water line. Thus there is a zone of shallow water with a sudden drop to deep water at its outer margin. Wave action is too severe here for the growth of *Potamogeton*, but the silted shelf supports *Chara* and filamentous algae.

Station 11 is along the west shore of a rounded peninsula. The low level land of the peninsula is much frequented by water birds. The station is exposed to the wind. No *Potamogeton* grows here. *Chara* is very scanty in growth but considerable quantities of *Stigeoclonium*, *Oedogonium*, and *Spirogyra* find lodgment among the grass rootlets which project from the sandy bottom offshore.

Station 12 is at the approximate center of the dam. The dam runs along the north end of the lake. Its rocks are continually beaten by waves. Long filaments of *Spirogyra* are attached to the rocks. This is practically the only genus found in the exposed portion of the dam. There are small quiet coves at the ends of the dam where other filamentous algae grow.

Collections and Methods

LITTORAL ALGAE

During the period from October 20, 1938 to December 15, 1939, thirty-four trips were made and collections taken at each of the twelve stations, with the exception of Stations 5 and 8. These were dry from April 8 and March 20, 1939 respectively so that collections could only be made prior to these dates.

In addition to these trips during the year 1939 others were made on the following dates: March 1, 8, 29, August 29, and November 29, 1940; November 14 and December 6, 1941; January 16, March 11, April 5, 10, 16, 17, 26, May 13, 20, June 14, and July 9, 1942; October 14 and December 3, 1943. Collections were taken on each trip at all stations except the dry stations 5 and 8 until November 14, 1941. After this date the collections were made at all twelve stations as the rains of 1941 had refilled 5 and 8. The additional twenty brings the total number of trips to fifty-four. The number of collections totals 616.

Collections were preserved immediately in small vials containing Transeau's solution (six parts water, three parts 95 percent ethyl alcohol, one part formalin). The collections, together with permanent slides made from them, are on file at the University of Oklahoma.

During the period from October 20, 1938 to December 15, 1939, the pH of each station was determined by the use of a La Motte colorimeter, and the temperature of soil and water were recorded on each trip. Notes were taken on the time of day, the amounts of sunshine, the sky condition, and precipitation, if any. The kinds of plants and animals present in the area were noted also.

On subsequent trips attention was concentrated upon collections. Temperature and pH records were omitted, but notes were kept on physical environment and biotic features.

Weather data, such as length of day, total sunshine, wind velocity, precipitation, and atmospheric temperature were obtained from the Federal Substation Weather Bureau at the University of Oklahoma, located one and one-half miles from Crystal Lake.

PHYTOPLANKTON

During the period from December 1941 to July 1943, monthly collections of plankton were made at one station at the point judged to be over the deepest part of the lake (see Map). On each trip ten-liter samples were taken with

a Kemmerer sampler at the surface and at depths of 1, 2, 3, 4, and 5 meters. The samples were concentrated to a few milliliters by straining through a number 20 silk bolting-cloth net. The concentrate was preserved immediately by the addition of five milliliters of formalin. The 48 collections are on file at the University of Oklahoma. Each collection was examined qualitatively and quantitatively. Enumeration was made with the aid of a Sedgewick-Rafter Counting Chamber and a Whipple ocular micrometer. A Bausch and Lomb microscope with a 10 x eyepiece an a 16 mm. objective was used.

Water samples for routine chemical analyses were also collected with a Kemmerer sampler. Analyses were made immediately upon return to the laboratory. Dissolved oxygen content was determined by the Rideal-Stewart modification of the Winkler method. Free carbon dioxide, bicarbonate, and carbonate were determined by the Seyler method. Hydrogen-ion concentration was measured by the use of the La Motte colorimeter.

On each trip the condition of the sky, the wind direction and velocity, and the air temperature were also recorded.

Detailed analysis of a sample of water collected December 4, 1943, was made by Dr. V. G. Heller, Head of the Department of Agricultural Chemistry Research, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma. The results are given in the following table:

Analysis of Lakewater Sample in Parts per Million.

Total Solids	142.
Phosphorus (P)	.03 (.09 PO_4)
Silica (SiO_9)	6.80
Sulfates (SO_4)	13.17
Bicarbonic Acid (HCO_3)	121.06
Chlorin (Cl)	10.00
Iron and Aluminum (Fe ÷ Al)	2.8
Calcium (Ca)	21.35
Magnesium (Mg)	6.89
Sodium (Na)	20.21

Results

PHYSICAL AND CHEMICAL FACTORS

The records show that the water was consistently alkaline at the twelve stations between October 1938 and December 1939. The greatest variation was shown at Station 9, which had reached the minimum pH of 7.2 in July and the maximum pH of 9.8 in May. The lower alkalinities at every station were found in July and December: the higher in May, September, October and November.

Variation of pH at the plankton station was even less than for the littoral stations. The lowest recorded figure was 7.6 at the depth of 5 meters in July, while the highest was 8.4 at all depths in May.

The lowest recorded water temperature at the stations along the shore line during the year 1939 was 0.55° C. in January; the highest was 34.4° C. in July. At the plankton station during 1942 the lowest recorded water temperature was 6.6° C. at four meters in January; the highest was 30° C. at the surface in July. No records were obtained during the month of February, as the lake was covered with ice.

Soil temperatures which were recorded in 1939 ranged at the surface from a minimum of 4.4° C. in January to a maximum of 40.1° C. in July. Air temperatures of the same year on days of collection ranged from a minimum of 3.2° C. in February 1939 to a maximum of 42.2° C. in September, 1939. These temperatures were obtained from the Federal Weather Substation located at the University of Oklahoma. The total sunshine per month during 1939 varied from one hundred forty-nine hours in February to three hundred thirty-two in July.

The oxygen content of water samples taken during 1942 varied from 4.1 parts per million at a depth of 4 meters in July to 10.5 parts per million at the same depth in January. Free carbon dioxide decreased from a maximum of 1.5 parts per million at the surface in January to a minimum of 0.0 parts per million in May, June, and July. Bicarbonates varied from a minimum of 6.0 parts per million at the surface in December, 1941, to a maximum of 8.5 parts per million at the surface in June, 1942. No carbonates were recorded until May. They varied from 0.2 to 0.5 parts per million during May, June, and July. Complete results are given in the following table:

Summary of Physical and Chemical Conditions in Crystal Lake.

Date	in Depth Meters	Temperature	ppm. Oxygen	ppm. Free CO_2	alkalinity M. O. ppm.	alkalinity Ph-th ppm.	pH
Dec. 17, 1941	0	7.0	10.00	1.0	60.0	0.0	8.0
	1	7.0	9.90	1.0	62.0	0.0	8.0
	2	7.0	9.90	1.0	61.0	0.0	8.0
	3	7.0	9.80	0.5	61.0	0.0	8.0
	4	7.0	9.90	0.5	67.0	0.0	8.0
	5	7.0	9.90	0.5	64.0	0.0	8.0
Jan. 23, 1942	0	7.1	10.30	5.0	65.0	0.0	8.0
	1	6.8	10.40	5.0	64.0	0.0	8.0
	2	6.8	10.50	2.0	65.0	0.0	8.0
	3	6.8	10.40	2.0	62.0	0.0	8.0
	4	6.7	10.50	2.0	63.0	0.0	8.0
Mch. 16, 1942	0	13.5	8.30	1.0	80.0	0.0	8.0
	1	13.5	8.50	1.0	78.0	0.0	8.0
	2	13.5	8.30	1.0	76.0	0.0	8.0
	4	13.5	8.60	1.0	76.0	0.0	8.0
Apr. 17, 1942	0	17.6	6.20	1.5	70.0	0.0	8.0
	1		7.30	1.5	66.0	0.0	8.0
	2		6.50	1.5	64.0	0.0	8.0
	3	17.2	6.60	1.5	67.0	0.0	8.0
	4		6.50	1.5	61.0	0.0	8.0
	5	16.5	6.60	1.5	65.0	0.0	8.0
May 17, 1942	0	22.5	7.30	0.0	68.4	4.0	8.4
	2		6.05	0.0	77.5	4.0	8.4

	3	22.5	6.65	0.0	74.0	3.0	8.4
	4		5.60	0.0	76.0	2.0	8.4
	5.5	22.5	6.35	0.0	79.3	3.0	8.4
June 19, 1942	0	28.0	5.60	0.0	85.0	4.0	8.2
	2	27.0	6.00	0.0	75.0	5.0	8.0
	3	27.0	6.10	0.0	71.0	2.0	8.2
	4	26.0	5.20	0.0	71.0	3.0	8.0
	5	24.0	5.50	0.0	73.0	3.0	7.6
July 26, 1942	0	30.0	6.20	0.0	62.0	3.0	8.2
	2	27.0	6.60	0.0	66.0	2.0	8.2
	3	27.0	5.00	0.0	50.0	2.0	8.2
	4	25.0	4.10	0.0	41.0	3.0	8.2

Weather conditions for 1939 varied somewhat from forty-seven year averages. Rainfall was deficient and high winds prevailed. January, however, had more rainfall than usual, and was abnormally warm. February was cooler, but precipitation was low. March was dry, with severe wind storms. April was warm and droughty. May, June, and July were abnormally warm. May and July were dry, but June had rainfall slightly above the average for the month. High temperatures and hot winds continued through July, August, and September. Mild temperatures and light rainfall came in October. Late frost and freezing weather ushered in November, which was cooler and drier than the average for that month.

COLLECTIONS

Chara evoluta Allen and *C. fragilis* Desv., as well as many of the eighteen recorded species of *Spirogyra* were found in varying quantities at some stations all the year round. During early spring, although it was practically ubiquitous, the growth of *Chara* was scanty. In May it became more abundant and attained its maximum vegetative growth during the autumn. By March, genera of the Desmidiaceae were plentiful, reaching a maximum in April. *Stigeoclonium amoenum* Kuetz. was present in almost as great amount as species of *Spirogyra* in April. Thirteen species of *Oedogonium* had been collected by the end of May, and occurred in large quantity, but genera of the Zygnemataceae were always present in greater quantity than other forms at this time. Their predominance continued through June, but as the weather grew warmer, they gave way to certain genera of the Myxophyceae. Of the filamentous forms, species of *Oscillatoria* were most plentiful. During the hottest months, the filamentous blue-green algae were found at all stations. A few of the blue-greens were identified to species, including those which form "water bloom." The main constituent of plankton in hot weather was *Coelosphaerium Naegelianum* Unger and the species which made up most of the "water bloom" of later fall was *Aphanizomen flos-aquae* (L.) Ralfs. Many diatoms were found at all stations throughout the year. Only eleven of these were identified to species. They are included in the taxonomic list.

Plankton collections showed the occurrence of a pulse in April and May, 1942. The increase of pulse throughout April was due to the presence of *Cryptoglena pigra* Ehr. The peak of the pulse reached in May was due to *Aphanizomenon flos-aquae*. Plankton species which have been identified are included in the taxonomic list.

Discussion

Data collected at Crystal Lake show it to be highly productive with respect to algae. The investigated environmental factors do not operate independently and so must be discussed in relation to one another. Some are favorable to production, some unfavorable, and others negligible in their effect.

The observations of Taft (1935) as to the coincidence of distribution of the Zygnemataceae with the prairie regions of Oklahoma are borne out by this study. He found, however, that pools in the Permian strata were extremely sterile, there being nothing more than *Rhizoclonium* in most of the habitats. He suggested that the availability of necessary mineral salts and the lack of permanent water supply might be the limiting factors. Crystal Lake is obviously an exception to Taft's generalization, as it is productive even though on one of the Permian formations. In this case the two suggested limiting factors are not operative.

The criteria for growth and maintenance of the Oedogoniales according to Tiffany (1937) are "relatively quiet water, including ponds, shallow parts of lakes, oxbows and sluggish streams provided with the necessary mineral salts; absence of shade; mud rather than sand or an easily movable bottom; a pH on the alkaline side; and a growing season of sufficient length to allow for completion of vegetative and reproductive cycles." These criteria are met in Crystal Lake.

The form of the basin in which the lake lies is undoubtedly an important factor. Extensive areas of shallow water do not absolutely insure productivity, but are conducive to biological productivity, as Welch (1935) points out. Crystal Lake has such extensive areas of shallow water forming ideal habitats for many kinds of algae.

Mechanical factors of exposure to wind and wave action are undoubtedly limiting with respect to both quantity and kind of algae. The steep exposed banks of Stations 6 and 10 are sterile in comparison to the sheltered shore lines of other stations. Station 11 is exposed to wind and wave also, but the water is shallow and the bottom is thickly studded with projecting roots and stems of higher plants which form habitats where filamentous algae with holdfasts can remain. The algae can also become entangled in the ends of these roots and stems protruding from the lake floor and thus accumulate. The holdfasts of the species of Spirogyra found in large quantity at Station 12 enable them to cling to the rocks of the dam in spite of violent wave action.

The high productivity of Station 9 may be partly due to the frequent presence of cattle whose droppings furnish mineral and organic constituents. Many investigators think that organic substances released by decomposition assist in the growth of phytoplankton. The large amount of decay consequent to abundant growth may release organic acids which could account for the low pH of Station 9 in July, while the high pH of this station in May might be due to the utilization of carbon dioxide during the period of increased photosynthetic activity at the spring maximum. The productivity of the exposed

Station 11 could be accounted for at least partially by the presence of organic matter from the droppings of birds which frequent the peninsula.

It seems probable that the higher aquatic vegetation along the shore line is a factor in productivity. At the station where there are wide zones of *Potamogeton,* for example, the filamentous forms are found in great numbers attached to the stems of this plant or living in the semi-shade of its leaves. Station 2, which is bordered by a bed of waterlilies in addition to the zone of *Potamogeton,* is one of the most highly productive stations. Rooted aquatic plants absorb mineral salts from the soil and upon their decay release them into the water where they may be utilized by other organisms. Raymond (1937) considers this process a major factor in productivity of plankton. The higher aquatic vegetation may also be used directly as food by aquatic animals. As such it functions indirectly in the oxygen-carbon dioxide cycle of green algae and animals. In the oxygen-carbon dioxide cycle too, must be considered the respiration of cells of roots and other non-green parts as well as the respiration of cells of green parts at night.

At the marginal stations no definite correlation could be established between seasonal periodicity and hydrogen-ion concentration although quantitative correlation was indicated. It would seem to be due simply to high photosynthetic activity and hence at the same time a low carbon dioxide content. Thus the relation is a reverse one, quantity of algae, through photosynthesis, controlling hydrogen-ion concentration.

Results of the chemical and physical analyses in connection with phytoplankton data which are given in the table do not require extensive comment. As shown by the table, the alkalinity was due almost entirely to bicarbonates, as the carbonates were either absent entirely or present in very small amounts.

The pH varied very little during the period of investigation. The water was consistently alkaline as in the case of the marginal stations. The slight rise in alkalinity coincided with the spring maximum. This was to be expected during a period of increased photosynthesis when the carbon dioxide was being used. As was expected also, the dissolved oxygen content varied inversely with the carbon dioxide content. Large areas of shallow water which present opportunity for solution of oxygen from the air account in part for the adequate amount of oxygen present. Photosynthetic activity also increases the oxygen content of the water.

Recent investigations of the photosynthesis of algae indicate that carbon dioxide is likely to be the limiting factor. Burr (1941) states that most ponds have a shortage of this gas in solution. The shortage is often due to its low concentration in the air above the water surface. Normally, carbon dioxide will enter the water one-twenty-eighth as fast as oxygen because there is less of it than the more slowly-diffusing but more abundant oxygen. According to Burr (1941) there may be enough base in alkaline waters to serve as a buffer and hold a sufficient supply of carbon dioxide for photosynthesis. Since solutes, temperature, light, and carbon dioxide tension operate simultaneously upon the

photosynthetic mechanism, precise records of each factor would be necessary to the problem of photosynthesis.

Temperature of the water, dependent mostly upon conduction, exhibited the expected seasonal variation. Consideration of the combined factors of air temperature and sunshine hours yields interesting if not conclusive data on seasonal sequence of algae. Months having total sunshine of between two hundred and three hundred hours and a mean temperature between 10° C. and 24° C. proved to be most favorable to vegetative growth of green algae. These were October and November of 1938 and March, April, May, June, October, and November of 1939. These months were also the times of greatest fruiting activity.

Months having total sunshine of over three hundred hours, average daily temperatures of 26° C., and high temperatures of 38° C., proved to be most favorable to growth of blue-green algae which were present in great quantities as well as variety during the months of July, August, and September.

Some data were obtained concerning periodicity of the algae of Crystal Lake. Transeau (1916) divided the algae into six groups with respect to periodicity. These are: winter annuals, spring annuals, summer annuals, autumn annuals, perennials, and ephemerals. Nine of the species of *Oedogonium* found in Crystal Lake are included by Tiffany and Transeau (1927) in their paper on *Oedogonium* periodicity in the north central states. In most cases, periodicity data agree with these of Tiffany and Transeau. *Oe. grande* (Kuetz.) Wittr. was found in fruiting condition in December. The latest month for fruiting of this form reported in the Tiffany and Transeau list was November. This might be explained by the difference in latitude. However, the fact that fruiting periods for *Oe. crassiusculum* Wittr. var. *idioandrosprorum* N. & H., *Oe. plagiostomum* Wittr., and *Oe. Wyliei* Tiffany coincide in the two lists, weakens this explanation. *Oe. Hirnii* Gutw. var. *africanum* G. S. West was collected with oospores in May. Tiffany and Transeau list it as a summer annual in July only. *Oe rufescens* Wittr. was collected with oospores in large quantities in December and January and in smaller amounts in August. Tiffany and Transeau list this form in March, April, May, June, and November, and it is classified as a spring annual with two broods.

Bulbochaete crenulata Pringsheim was found in fruiting condition in April and November. *Bulbochaete varians* Wittr. was found in fruiting condition in April.

Vaucheria terrestris (Vauch.) De Candolle was collected in April with oogonia and antheridia. *Vaucheria geminata* (Vauch.) De Candolle was in fruiting condition when collected in November. *Volvox aureus* Ehrenberg, was collected in fruiting condition in December and March. *Volvox perglobator* Powers showed ripe oospores in July.

The fruiting of *Chara* occurred at the time of its most luxuriant vegetative growth, which was during the summer and autumn months. This statement applies to both species of *Chara* found in the lake: *Chara fragilis* Desv. and

Chara evoluta Allen. The first record was made in July and fruiting continued until the time when cold weather killed the vegetative plants.

The data on periodicity of the algae of the order Zygnematales agreed with those of Transeau (1916). Three of the species of *Spirogyra* found in Crystal Lake were also included in Transeau's list. One of these species, *Spirogyra tenuissima* (Hass. Kuetz.) was found with spores at the same time as the same species in central Illinois. The second and third species, *Spirogyra Juergensii* Kuetz. and *S. setiformis* (Roth) Kuetz., were found with spores a month earlier than the same species in Illinois. These are not significant differences as the more southern latitude of Oklahoma might allow the slightly earlier fruiting.

A check was made of the available taxonomic lists of the algae from the states north of Oklahoma in the central flyway for water fowl, during migration. The purpose was to find out whether or not there might be a possibility of spores or fragments of algae being carried from lake to lake by birds.

The eastern boundary of the central flyway roughly follows the ninety-fifth meridian. Its western boundary starts at the Bear River Marshes on the north side of the Great Salt Lake. The Bear River Marshes are one of the great breeding grounds for waterfowl. Three routes leave this region in an easterly direction. One of these routes crosses the central flyway to join the Atlantic flyway. Since the Mississippi flyway overlaps the eastern border of the central flyway, some of the birds recorded in Oklahoma really belong to the Mississippi migration routes.

The data collected were inconclusive for two reasons: the first is that the path of the birds is too indefinite on account of branching and marginal overlapping of flyways; the second is that the taxonomic lists of states to the north are lacking or incomplete. Thirty-nine species of the list of two hundred forty-one algae from eastern Kansas reported by Thompson (1938) were found in Crystal Lake. The genus *Cosmarium* had the greatest percent of coincidence.

Thirty-four of the two hundred and forty-three species reported from Wyoming by Giles (1934) and Miller (1936) were found. Here again the greatest percent of coincidence was in the Desmidiaceae. The records of five hundred and nineteen species of algae from Iowa reported by Prescott (1931) include sixty found in Crystal Lake. Ninety-three of the Crystal Lake algae were already on the records for the state.

The total number of species and varieties of algae identified from the collections of littoral algae and plankton is two hundred and eight. Of this number one hundred and eighteen are new records for the state. Sixteen orders of the classes Myxophyceae, Chlorophyceae, Euglenophyceae, Dinophyceae, Chrysophyceae, and Bacillariophyceae are represented. The records of Myxophyceae and Bacillariophyceae are by no means complete. Although the number of representatives of the Chlorophyceae far exceeds that of the other classes, even this group cannot be said to be completely recorded for Crystal Lake.

In the taxonomic list which follows, the name of each species and variety which is a new record for the state is preceded by an asterisk. Species of the Desmidiaceae were reported in the 1944 Proceedings of the Oklahoma Academy of Science and are included so that the list of Zygnematales may be complete.

Taxonomic List

MYXOPHYCEAE

Chroococcales

Coelosphaerium Naegelianum Unger
Gomphosphaeria aponina Kuetz.
Merismopedia elegans A. Braun

Hormogonales

Anabaena circinalis (Kuetz.) Rab.
**Aphanizomenon flos-aquae* (L.) Ralfs
**Lyngbya contorta* Lemm.
Oscillatoria formosa Bory
Spirulina major Kuetz.

CHLOROPHYCEAE

Volvocales

Eudorina elegans Ehr.
**Volvox aureus* Ehr.
**Volvox perglobator* Powers

Tetrasporales

Sphaerocystis Schroeteri Chod.
**Stylosphaeridium stipitatum* (Bachm.) Geitler & Gimesi
Tetraspora lacustris Lemm.

Ulotrichales

Aphanochaete repens A. Braun
**Aphanochaete vermiculoides* Wolle
Chaetosphaeridium globosum (Nordst.) Klebahn
Chaetophora elegans (Roth) Agardh
**Coleochaete orbicularis* Pringsh.
Hormidium sp.
Stigeoclonium amoenum Kuetz.
**Ulothrix subconstricta* G. S. West

Cladophorales

**Basicladia Chelonum* (Collins) Hoffman and Tilden
Basicladia crassa Hoffman and Tilden
**Rhizoclonium crassipellitum* W. and G. S. West
**Rhizoclonium crispum* Kuetz.

Oedogoniales

Bulbochaete crenulata Pringsh.
**Bulbochaete varians* Wittr.
Oedogonium borisianum (LeClerc) Wittr.
Oedogonium crassiusculum var. *Arechavaletae* (Wittr.) Hirn
Oedogonium crassiusculum var. *cataractum* (Wolle) Tiffany
Oedogoniumcrassiusculum var. *idio-androsporum* Nordst. & Wittr.
Oedogonium crassiusculum var. *idio-*
Oedogonium echinospermum A. Braun
Oedogonium grande (Kuetz.) Wittr.
Oedogonium grande var. *angustum* Hirn
Oedogonium hirnii var. *africanum* G. S. West
**Oedogonium plagiostomum* Wittr.
**Oedogonium rufescens* Wittr.
Oedogonium rufescens var. *exiguum* (Elfv.) Tiffany
**Oedogonium Wyliei* Tiffany

Zygnematales

Sirogonium sticticum (Engl. Bot.) Kuetz.
**Sirigonium tenuius* (Nordst.) Transeau
Spirogyra affinis (Hass.) Petit
**Spirogyra Cleveana* Transeau
Spirogyra corrugata Transeau
**Spirogyra communis* (Hass.) Kuetz.
**Spirogyra crassoidea* Transeau
**Spirogyra fragilis* Jao
**Spirogyra fluviatilis* Hilse
**Spirogyra intorta* Transeau
Spirogyra Juergensii Kuetz.
Spirogyra Lagerheimii Wittr.
Spirogyra longata (Vauch.) Kuetz.
**Spirogyra neglecta* (Hass.) Kuetz.
Spirogyra porticalis (Mueller) Cleve
**Spirogyra pratensis* Transeau
**Spirogyra punctata* Cleve
**Spirogyra quadrilaminata* Transeau
**Spirogyra semiornata* Jao
Spirogyra setiformis (Roth) Kuetz.
Spirogyra tenuissima (Hass.) Kuetz.
**Cylindrocystis americana* W. and G. S. West var. *minor* Cushman
**Mesotaenium Endlicherianum* Nag.
**Netrium oblongum* (De Bary) Lutkem.
Closterium acerosum (Schrank) Ehr.

* New records for Oklahoma.

Closterium acerosum var. *elongatum* Breb.
Closterium calosporum Wittr.
Closterium calosporum Wittr. forma *major* W. and G. S. West
Closterium Dianae Ehr.
Closterium Dianae var. *arcuatum* (Breb.) Rab.
Closterium Ehrenbergii Menegh.
Closterium gracile Breb.
Closterium gracile var. *elongatum* W. and G. S. West
Closterium incurvum Breb.
Closterium lanceolatum Kuetz.
Closterium Leibleinii Kuetz.
Closterium moniliferum (Bory) Ehr.
Closterium parvulum Nag. forma *sigmoideum* Irenee-Marie
Penium margaritaceum (Ehr.) Breb.
Penium minutum (Ralfs) Cleve
Pleurotaenium Ehrenbergii var. *Undulatum* Schaarschm.
Pleurotaenium maximum (Reinsch) Lund.
Pleurotaenium Trabecula (Ehr.) Nag.
Pleurotaenium Trabecula (Ehr.) Nag. forma *clavata* (Kuetz.) W and G. S. West
Pleurotaenium Trabecula (Ehr.) Nag. forma *granulata* G. S. West
Euastrum binale (Turp.) Ehr.
Euastrum denticulatum (Kirchn.) Gay
Euastrum insulare (Wittr.) Roy
Euastrum spinosum Ralfs
Euastrum verrucosum Ehr.
Micrasterias truncata (Corda) Breb.
Cosmarium abruptum Lund.
Cosmarium angulare Johnson
Cosmarium Botrytis Menegh.
Cosmarium Botrytis var. *subtumidum* Wittr.
Cosmarium fontigenum Nordst.
Cosmarium gayanum DeToni
Cosmarium granatum Breb.
Cosmarium granatum var. *subangu'are* W. and G. S. West
Cosmarium granatum var. *subgranatum* Nordst.
Cosmarium humili var. *substriatum* (Nordst.) Schmidle
Cosmarium impressulum Elfv.
Cosmarium margaritiferum Menegh.
Cosmarium moni iforme (Turp.) Ralfs
Cosmarium moniliforme forma *punctata* Lagerh.
Cosmarium obtusatum Schmidle
Cosmarium obtusatum var. *Beandandii* W. and G. S. West
Cosmarium polygonum (Nag.) Archer
Cosmarium portianum Archer
Cosmarium Pseudobroomei Wolle
Cosmarium pseudoprotuberans Kirchner
Cosmarium pseudopyramidatum Lund.
Cosmarium punctulatum var. *subpunctulatum* (Nordst.) Bory
Cosmarium pusillum (Breb.) Archer
Cosmarium pygaeum Archer
Cosmarium quadrum Lund.
Cosmarium quinarium Lund.
Cosmarium reniforme (Ralfs) Archer
Cosmarium sexangulare Lund.
Cosmarium sexangulare var. *minima* Nordst.
Cosmarium Sportella Breb.
Cosmarium Subbroomei Schmidle
Cosmarium subcostatum Nordst. forma *minor* W. and G. S. West
Cosmarium subcrenatum Hantzsch.
Cosmarium subcrenatum var. *divaricatum* Wille
Cosmarium subcucumis Schmidle
Cosmarium trachydermum W. and G. S. West
Cosmarium triplicatum Wolle
Cosmarium venustum (Breb.) Archer forma *minor* Wille
Cosmarium vexatum West
Dichotomum elegans West
Staurastrum alternans Breb.
Staurastrum anatinum var. *biradiatum* West
Staurastrum Cerastes Lund.
Staurastrum Clepsydra Nordst.
Staurastrum cuspidatum Breb.
Staurastrum cyrtocerum Breb.
Staurastrum dejectum var. *patens* Nordst.
Staurastrum dilatatum Ehr.
Staurastrum gracile Ralfs
Staurastrum gracile var. *coronulatum* Boldt.
Staurastrum Manfeldtii Delp.
Staurastrum margaritaceum (Ehr.) Menegh.
Staurastrum natator W. West
Staurastrum paradoxum var. *evolutum* W. and G. S. West
Staurastrum polymorphum Breb.
Staurastrum punctulata Breb.
Staurastrum setigerum Cleve
Staurastrum setigerum var. ?
Staurastrum spiculiferum G. M. Smith
Staurastrum striolatum (Nag.) Archer
Anthrodesmum octocornes Ehr.
Onychonema laeve Nordst.
Spondylosum planum (Wolle) W. and G. S. West

* New records for Oklahoma.

Hyalotheca dissiliens (Schmidle) Breb.
Hyalotheca mucosa (Dillw.) Ehr.
**Desmidium Aptogonium* Breb.
Desmidium Schwartzii Agardh

Chlorococcales

Ankistrodesmus spiralis (Turner) Lemm.
**Characium angustatum* A. Braun
Coelastrum microporum Nag.
**Kirchneriella contorta* (Schmidle) Bohlin
**Kirchneriella elongata* G. M. Smith
Nephrocytium Agardhianum Nag.
**Nephrocytium ecdysiscepanum* W. and G. S. West
Oocystis Borgei Snow
**Oocystis solitaria* Wittr.
**Pediastrum biradiatum* Meyen
Pediastrum duplex var. *clathratum* (A. Braun) Lagerh.
**Pediastrum duplex* var. *reticulatum* Lagerh.
Pediastrum tetras (Ehr.) Ralfs
**Pediastrum tetras* var. *tetraodon* (Corda) Hansgirg
Scenedesmus arcuatus var. *platydisca* G. M. Smith
Scenedesmus bijuga (Turp.) Lagerh.
Scenesdesmus quadricauda (Turp.) Breb.
**Sorastrum americanum* (Bohlin) Schmidle
Sorastrum spinulosum Nag.
Tetraedron gracile (Reinsch) Hansgirg
**Tetraedron regulare* var. *torsum* (Turner) Brun
**Trochiscia vestitus* Reinsch

Siphonales

Vaucheria geminata (Vauch.) DeCandolle
**Vaucheria terrestris* (Vauch.) DeCandolle

Charales

**Chara evoluta Allen*
**Chara fragilis* Desv

EUGLENOPHYCEAE

Euglenales

**Cryptoglena pigra* Ehr.
**Euglena gracilis* Klebs
**Phacus acuminatus* Stokes
**Phacus longicauda* (Ehr.) Duj.
**Phacus longicauda* var. *torta* Lemm.
**Trachelomonas hispida* (Perty) Stein
**Trachelomonas oblonga* Lemm.
**Trachelomonas volvocina* Ehr.

DINOPHYCEAE

Peridiniales

**Ceratium hirundinella* (O. F. Muller) Schrank
**Peridinium Volzi* Lemm.
**Peridinium Willei* (Huntfeldt) Kass.

CHRYSOPHYCEAE

Chrysomonadales

**Dinobryon Tabellariae* (Lemm.) Pascher

BACILLARIOPHYCEAE

Centrales

Cocconeis placentula Ehr.
**Cyclotella antiqua* W. Sm.

Pennales

**Cystopleura gibba* (Ehr.) Kuntze
**Cystopleura turgida* (Ehr.) Kuntze
**Cystopleura ventricosa* (Kuetz.) Elmore
**Gomphonema constrictum* Ehr.
**Gomphonema olivaceum* (Lyngb.) Kuetz.
**Homoeocladia sigma* (Kuetz.) Kuntze
**Homoeocladia tryblionella* (Hantz.) Kuntze
**Navicula gracilis* Ehr.
**Synedra ulna* (Nitzsche) Ehr.

Summary

Investigations of the algae of Crystal Lake, Cleveland County, Oklahoma, extending over a period of five years, included taxonomic, physical, and ecological studies.

Crystal Lake is an artificial lake located on the Permian redbeds. It covers an area of about twenty-four acres. Its average depth is about five feet. The drainage area surrounding it supports the mixed-grass prairie type of vegetation. The ground cover is adequate to prevent erosion and consequent turbidity of the water. Water birds visit the lake in great numbers during periods of migration.

Collections were made at twelve stations along the margin of the lake. These stations were selected to represent varied types of habitats. One station, used for the collection of phytoplankton, was located at the point judged to be over the deepest part of the lake.

Data on temperature of air and water, on climate, and weather conditions were assembled. The factors of hydrogen-ion concentration, dissolved gases, and dissolved minerals in the water were studied with reference to their possible effect upon the algal flora. Coactions with higher plants and with animals were investigated.

Crystal Lake was found to be highly productive with respect to algae. Some of the factors which make it so are: (1) occurrence of extensive areas of shallow water; (2) the number of places protected from the violence of wave action; (3) the presence of dissolved minerals and organic matter in the water; and (4) the abundance of higher aquatic vegetation along the margin of the lake.

The reaction of the water was consistently alkaline. Bicarbonates were present in moderate quantity. Carbonates were entirely lacking or present in small quantity. The supply of oxygen was adequate.

Months with two hundred to three hundred hours of sunshine and a mean temperature between 10° C. and 24° C. were found to be most favorable to growth and fruiting of green algae. Months having over three hundred hours of sunshine and average temperatures of 26° C. were found to be most favorable to growth of blue-green algae. The records of the phytoplankton collections show a pulse in May.

Data were obtained concerning periodicity of the Volvocaceae, Oedogoniaceae, Zygnemataceae, Characeae, and Vaucheriaceae.

Some evidence was collected which showed that water birds may carry spores or fragments of algae from lake to lake along the path of their migration.

The total number of species and varieties found in Crystal Lake was two hundred and eight. Of these one hundred and eighteen are new records for Oklahoma.

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Plankton Studies of Lake Michigan

I. Seventeen Years of Plankton Data Collected at Chicago, Illinois[1]

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Introduction

As early as 1845 Johannes Muller began studying the microscopic organisms occurring in the North Sea. However, it remained for Hensen in 1887 to propose the term plankton to include that heterogeneous assemblage of drifting microscopic organisms suspended in natural waters. Almost since the very first discovery of these plankton organisms, there has been a challenge to explain their occurrence, their distribution, and their seasonal variation. It has been only through continued and repeated research on numerous bodies of water that some of the various phases of plankton activity have been established.

Most of the plankton studies completed to date have been seasonal or annual investigations with sampling being carried on weekly and sometimes only monthly during disagreeable winter months. The writer (1941) made such an investigation at Evanston, Illinois with the thought of becoming acquainted with some of the quantitative aspects of Lake Michigan plankton. Even though the study followed a similar investigation (Daily, 1938), there were several factors operating to prevent the securing of a very representative picture of the true plankton activity in Lake Michigan. All of the collections were made from a single shoreline collecting station which was located in rather shallow water. Thus, with only moderate wave action a rather disturbed

1 A portion of the work done in partial fulfillment of the requirements for a Ph.D. in Botany at Northwestern University, Evanston, Illinois, 1943.

environment resulted in which the turbidity was high and the light penetration was extremely low. When a weekly collection was made under such conditions, the number of plankton encountered was usually quite different than on a day prior to such a disturbance. More frequent sampling and the establishment of a deep water collecting station might have given a more complete picture of the Lake Michigan plankton at Evanston, Illinois. However, the lack of accompanying data covering turbidity, water temperature, wind movement, light penetration, mineral elements, bacterial populations, etc., limited the degree to which the plankton activity could be interpreted. Such a program involving the collection of data covering the many factors of the environment is almost beyond the part-time research activity of one individual. Fortunately, the availability of plankton records plus numerous accompanying data recorded by the City of Chicago have made possible the immediate evaluation of Lake Michigan plankton occurring over seventeen consecutive years.

The Chicago plankton program was initiated by the Water Purification Division of the City during May, 1926. Four permanent deep-water collecting stations were established and in the years 1926 through 1942 over 12,000 collections were made. Along with the plankton examinations, very complete records were kept of water temperatures, turbidities, wind movements, chemical analyses, lake levels, bacterial populations, etc. The entire program is still being carried on actively; but due to the profuse amount of data already accumulated, the annual plankton records through 1942 only have been analyzed in this report. In preparation are papers related specifically to the seasonal periodicity of the plankton occurring in Lake Michigan at Chicago; the effects of pollution on the plankton of Lake Michigan at Chicago; the experimental effects of light and water temperature on Lake Michigan plankton; and a comparative study of the plankton occurring in Lake Michigan at Milwaukee, Wisconsin; Michigan City, Indiana; and Chicago, Illinois.

Review of Literature

Several papers have been published listing the plankton organisms found in Lake Michigan but there is none which deals with the quantitative approach over an extended period of time. Briggs (1872) and Thomas and Chase (1887) compiled long lists of diatoms found in Lake Michigan at Chicago. Ward (1896) investigated the relationship of plankton and bottom organisms to whitefish production in the Traverse Bay Region, which is in the extreme north end of the lake. Jennings (1896), Thompson (1896), and Kofoid (1896) added appendices on rotifers, phytoplankton, and protoza respectively to Ward's publication.

Eddy (1927) published the first quantitative data from Lake Michigan in the Chicago area. His material was obtained from two series of collections made in 1887-88 and 1926-27 at various points along the lake shore, mostly in the immediate vicinity of Chicago. By comparing the more recent collections with those made forty years previous, he found very little change in the constituent species of the plankton. He did note that the phytoplankton appeared to be constant and uniform throughout the year, but the zooplankton showed

response to seasonal variation. Several authors (Baylis and Gerstein, 1929; Ahlstrom, 1936; Daily, 1938; and Damann, 1941) have since noted distinct seasonal variation in the phytoplankton of Lake Michigan.

Not directly associated with the plankton production of this program, but certainly important in dealing with the biology of Lake Michigan, is the work of Eggleton (1936, 1937). At the request of the Great Lakes Fisheries Investigations of the United States Bureau of Fisheries, he studied bottom fauna samples taken from the deeper water of Lake Michigan. He found that the benthic population was composed of relatively few species but many individuals. A pronounced concentration zone occurred between thirty-five and fifty meters with the maximum population at forty-two meters. In 1932, the density of the benthic population increased through May, then suddenly decreased in June to a midsummer minimum in July. A pronounced increase followed in August. It is interesting to note that during 1932, the plankton in the Chicago Region of Lake Michigan demonstrated a similar trend in yield.

Skvortzow (1937) listed seventeen species and varieties of diatoms as being present in Lake Michigan water taken from the city mains of Chicago by the Field Museum of Natural History during January, 1936. Species of the genera Stephanodiscus and Cyclotella were the only forms listed as found. Such a limited occurrence of genera does not correspond to the data collected by the Water Purification Division of the City of Chicago which listed a total of thirteen genera of diatoms as occurring in the city water supply during January of 1936. In fact, it is rare not to find either a specimen of Fragilaria, Tabellaria, Asterionella, Synedra or Melosira during any month of the year in the Chicago water supply.

The more recent and probably the most complete limnological work attempted on any of the Great Lakes has been done by Chandler (1940, 1942a and 1942b) on western Lake Erie. Emphasis was placed on the relationship between the plankton and physical-chemical data. Specific references will be made to his work later in this study.

Lackey (1944) has published the most recent work on Lake Michigan in a report on the quality and quantity of the plankton occurring in the south end of Lake Michigan during 1942. His paper has incited several questions which appear to be related to the data discussed herein and will be of value in planning future research on Lake Michigan plankton.

Area of Lake Studied

The size of Lake Michigan practically prohibits a complete survey of its waters. The lake occupies approximately 22,000 square miles with a length of 300 miles and an average width of approximately fifty miles. Obviously, then, the plankton data collected in any region reflect only the conditions in that region and should not be interpreted as an expression of the plankton population of Lake Michigan as a whole. The general character of Lake Michigan and the location of the Chicago Region is represented in Fig. 1. Thus, it should be evident that the data contained herein are an expression of the plankton activity in only a small portion of the southwestern corner of Lake Michigan.

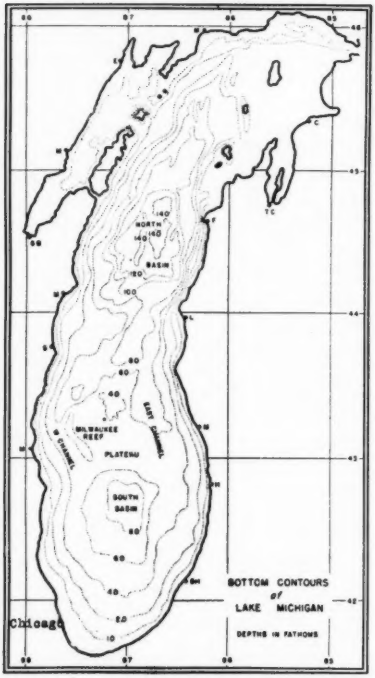

Fig. 1. The Structure of Lake Michigan. (From Church, 1942.)

COLLECTING STATIONS

The water supply system of the City of Chicago has a long and interesting history.[2] As early as 1867 it was necessary to construct a tunnel underneath the lake bed for a distance of two miles from shore in order to secure an unpolluted water supply. This tunnel terminated in a permanently housed structure known as a crib. A typical cross section of such a system is shown in Fig. 3. The venture proved so successful that four tunnel systems and cribs were put into operation by 1900. At present six such cribs are in use. However, they are so located that plankton collections from four of the cribs provide representative sampling of the Chicago area of the lake. The cribs serving as collecting stations are Dunne, Four-Mile, Dever, and Wilson all of which are located at least two miles from shore and somewhere between 68th Street on the south side of the City and Wilson Avenue on the north side (Fig. 2). Detailed information pertaining to the four collecting stations comprises Table 1.

2 Hewitt, O., et al. 1933. *A Century of Progress in Water Works, 1833-1933.* (Bureau of Engineering, Dept. of Public Works, Chicago, Illinois).

TABLE 1.—The Chicago plankton collecting stations on Lake Michigan.

Cribs:	Dunne	Four-Mile	Dever	Wilson
Station No:	1	2	3	4
Location Opposite:	68th St.	Roosevelt Rd.	Ccicago Ave.	Wilson Ave.
Distance from shore:	10.525 ft.	16,600 ft.	13,800 ft.	11,000 ft.
Depth of lake:	32 ft.	38 ft.	34 ft.	33 ft.
Depth of intakes:	18 ft.	29 ft.	25 ft.	22 ft.
Capacity of crib:	253 MGD	65 MGD	342 MGD	300 MGD

MGD = Million gallons per day.

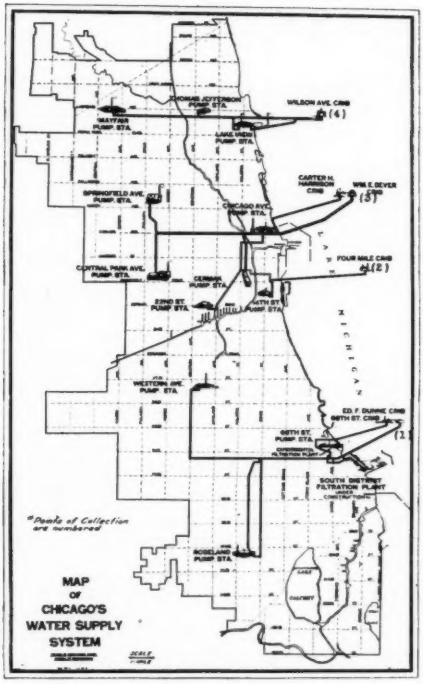

Fig. 2. Chicago Plankton Collecting Stations.*

FREQUENCY OF SAMPLING

More than 12,000 plankton samples have been taken from the four collecting stations since the plankton examination program was started in 1926 (Table 2). This total would make the average weekly number of collections over three per crib. Actually, however, collections are usually made much more frequently during late spring, summer, and fall months when troublesome organisms are apt to abound and less frequently during winter and early spring months.

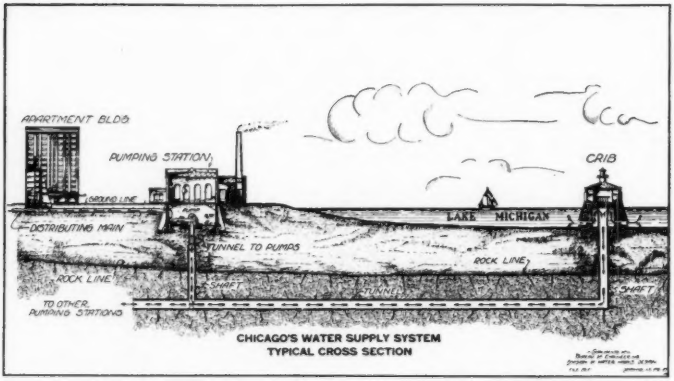

Fig. 3. Chicago's Water Supply System. Typical Cross Section.

TABLE 2.—Total number of collections per year from four stations on Lake Michigan at Chicago, Illinois.

1926	795	1932	770	1938	552
1927	1234	1933	755	1939	368
1928	918	1934	769	1940	655
1929	782	1935	950	1941	615
1930	779	1936	689	1942	241
1931	770	1937	596		
				Grand Total	12,238

TREATMENT OF PLANKTON

The Plankton counting system initiated by the Water Purification Division of the City of Chicago probably can be most easily described by referring to a typical monthly summary (Fig. 4). The organisms have been considered as members of the following groups:

Group 1. Bacillariaceae
Group 2. Chlorophyceae
Group 3. Protozoa
Group 4. Rotifera
Group 5. Crustaceae
Group 6. Miscellaneous

METHOD OF COUNTING

The abundance of the various plankton organisms has been determined in both number and volume units per cubic centimeter of water examined. These

CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
WATER PURIFICATION DIVISION

SUMMARY OF AVERAGE PLANKTON CONTENT OF PUBLIC WATER SUPPLY

MONTH OF AUGUST 1937

WATER TEMPERATURE RANGE 69.3°F TO 73.7°F (HOURS OF SUNSHINE 339.9 HRS) VOLUME OF ORGANISMS IN CUBIC UNITS PER C.C.

NUMBER OF SAMPLES EXAMINED		13		13		13		13		AVERAGE	
	ORGANISMS.	WILSON AV CRIB LAKEVIEW R.1		DEVER CRIB CHICAGO AV R.1		9 MILE CRIB 14TH ST. M-1		DUNNE CRIB 68TH ST R-4			
		NUMBER	VOLUME	NUMBER	VOLUME	NUMBER	VOLUME	NUMBER	VOLUME	NUMBER	VOLUME
BACILLARIACEAE	AMPHIPRORA	0	0	.5	.5	0	0	.5	.9	.25	.35
	AMPHORA	.5	.5	.5	.2	0	0	0	0	.25	.18
	ASTERIONELLA	43.9	8.8	35.1	7.4	44.8	9.0	26.3	5.5	37.53	7.68
	CYCLOTELLA	.5	.2	4.6	.9	1.9	.4	1.9	.4	2.23	.48
	CYMATOPLEURA	0	0	0	0	.5	1.4	0	0	.13	.35
	FRAGILARIA	270.5	55.9	362.8	78.8	327.7	73.5	386.8	78.1	334.45	71.58
	MELOSIRA	.5	.9	1.4	4.2	3.7	7.2	4.2	6.5	2.45	4.70
	NAVICULA	2.3	2.3	1.4	9	.9	.5	0	0	1.15	.93
	NITZSCHIA	0	0	0	0	0	0	.9	.5	.23	.13
	RHIZOSOLENIA	3.2	.1.3	2.8	1.4	1.9	.9	.5	.2	2.10	.95
	STEPHANODISCUS	2.8	4.3	9	1.3	2.8	3.4	1.9	3.1	2.10	3.03
	SYNEDRA	63.2	18.9	68.3	18.9	32.2	17.9	82.6	21.6	66.38	19.70
	TABELLARIA	183.7	94.5	142.2	73.3	121.4	62.5	137.9	82.3	151.30	78.16
	UNIDENTIFIED	0	0	.5	.2	.5	2.8	0	0	.25	.75
	TOTAL	571.1	187.6	621.0	188.0	558.3	179.0	663.5	199.1	603.98	188.43
CHLOROPHYCIAE	BOTRYOCOCCUS	1.4	1.2	.5	.5	0	0	.5	.2	.60	.56
	CONFERVA (or Tribonema)	0	0	0	0	0	0	0	0	0	0
	DICTYOSPHAERIUM	.5	.7	0	0	5	1.9	0	0	.25	.65
	HORMIDIUM	0	0	0	0	.5	.9	.5	.6	.25	.38
	PEDIASTRUM	0	0	0	0	0	0	.5	.3	.13	.08
	SCENEDESMUS	0	0	0	0	.5	.1	.9	.2	.35	.08
	SPHAEROCYSTIS	0	0	.5	.7	0	0	.5	.5	.25	.30
	SPHAEROZOSMA	.5	.5	1.4	1.6	.5	.2	1.4	1.2	.95	.88
	TRIBONEMA	0	0	0	0	0	0	1.4	2.3	.35	.58
	TOTAL	2.4	2.4	2.4	2.8	2.0	3.1	5.7	5.3	3.13	3.40
PROTOZOA	CERATIUM	.5	2.8	.9	3.4	.5	2.2	.9	3.0	.70	2.85
	DIFFLUGIA	0	0	.5	.7	.5	2.3	.5	.5	.38	.88
	DINOBRYON	74.3	14.9	66.3	13.3	102.9	20.6	132.5	26.5	94.05	18.83
	GLENODINIUM	0	0	0	0	.5	.4	0	0	.13	.10
	PERIDINIUM	0	0	.5	1.9	0	0	0	0	.13	.49
	VORTICELLA	1.4	1.4	0	0	0	0	0	0	.35	.35
	UNIDENTIFIED	0	0	.5	.2	0	0	0	0	.13	.05
	TOTAL	76.2	19.1	68.9	19.5	104.4	25.5	133.9	30.0	95.85	23.53
ROTIFERA	ANURAEA	0	.4	0	.3	0	.3	0	.1	0	.23
	FLOSCULARIA	0	.2	0	0	0	.1	0	0	0	.08
	NOTHOLCA LONGISPINA	0	.1	0	0	0	.1	0	0	0	.03
	POLYARTHRA	0	.3	0	0	0	0	0	.2	0	.13
	TOTAL	0	1.0	0	.3	0	.5	0	.3	0	.58
CRUSTACEA	CYCLOPS	0	0	0	5.3	0	1.4	0	3.3	0	2.35
	DIAPTOMUS	0	12.4	0	0	0	0	0	4.6	0	4.25
	TOTAL	0	12.4	0	5.3	0	1.4	0	8.1	0	6.80
MISCELLANEOUS	AMORPHOUS MATTER	47.5	46.4	39.7	51.2	47.1	62.5	24.0	37.6	39.58	49.43
	AEOLOSOMA	0	0	0	0	0	.5	0	0	0	.13
	ANABAENA	.3	1.4	0	0	0	0	0	0	.13	.35
	BRYOZOA	0	0	0	0	0	180.0	0	0	0	45.00
	CHAETOGASTER	0	0	0	0	0	.4	0	0	0	.10
	HYDRA	0	.3	0	0	0	8.7	0	0	0	2.30
	UNIDENTIFIED	.3	1.9	.3	1.2	0	0	0	0	.25	.78
	TOTAL	48.5	50.2	40.2	52.4	47.1	252.1	24.0	37.6	39.95	98.08
TOTAL NUMBER OF PLANKTON PER C.C. WATER		698.2		732.5		711.8		827.1		748.40	
TOTAL VOLUME OF PLANKTON PER C.C. WATER			278.7		268.3		461.6		280.4		322.05

ALL RESULTS ARE EXPRESSED AS NUMBER AND VOLUME OF PLANKTON PER C.C. OF WATER EXAMINED.

Sanitary Engineer, H. W. Streeter
Engineer of Water Purification, E. E. Hoffman

ORIGINAL ENTRY: F.R. CHECKED: F.F. CALCULATED: F.R. VERIFIED: T.S.

EEL

Fig. 4. The monthly plankton summary form used by the Water Purification Division of the City of Chicago.

results are then summarized monthly for each organism at each of the stations together wiith an average yield of each organism at all of the stations combined. Such a system of recording the data provides numerous possibilities for correlation of plankton activity in the Chicago area of Lake Michigan.

Much controversy has arisen over the methods employed in counting plankton and with the success of correlating the works of various authors on biological productivity. The results often depend not only upon the methods used, but also upon the individuals doing the counting. Fortunately, the Chicago personnel instrumental in developing the system now in use realized the need for the establishment of a very definite procedure. All plankton counting over the entire period has been done by the Chicago Department of Health. For ten of the seventeen years the plankton counting has been under the responsible direction of the same person.

The water samples are concentrated by filtering through sand supported upon a plankton silk disc. Following the concentration, the Sedgwick-Rafter cell is employed in counting. The procedure followed is as outlined in the "Standard Methods of Water Analysis."[3]

Up to the point of actual enumeration of the plankton, there is little chance for the personal equation to become much of a factor as the method used has been fairly well standardized. Inasmuch as there seems to be no uniform procedure for the actual measurement of organisms, the part of the counter then becomes extremely important.

Such organisms as occur in clusters or colonies and are easily broken apart are counted as one organism for each cell. This group includes Asterionella, Tabellaria, Dinobryon, Fragilaria, Synedra, and others of similar organization. Other organisms that occur in filaments such as Melosira, Oscillatoria, Anabæna, Aphanizomenon, Ulothrix, etc., are counted as one organism for each 100 microns in length. With the volume counts, the area of individual cells and not the entire area covered by a colony like Dinobryon or Asterionella is used. Whenever the length of an organism is considerably greater than the diameter, it is measured as a cylinder and if less, it is measured as a sphere. After determining whether the organism is a cylinder or a sphere, the volume of the organism in cubic standard units is computed by use of a standard procedure.[4]. A cubic standard unit is the equivalent of a cube $20\mu x20\mu x20\mu$ or 8,000 cubic microns.

What is a Plankton Yield?

The numerical frequency of occurrence of plankton organisms per unit volume of water, as determined by the Sedgwick-Rafter method of concentration, has been expressed as the yield of plankton. With this abundance or frequency of plankton expressed in volume units, the use of the term "yield"

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3 American Public Health Association. 1943. *Standard methods for the examination of water and sewage*. Eighth Edition. New York

4 Baylis, J. R., and H. H. Gerstein. 1929. "Micro-organisms in the Lake Water at Chicago." *Municipal News and Water Works* **76**:291-296.

would be synonomous with "crop" which we customarily think of as tons per acre, bushels per acre, etc. The use of the term yield in this discussion, however, will be restricted to the increase in number and kind of organisms without regard to the change in volume of the organisms. There will be no occasion for the direct use of the term crop. The mere increase and decrease of organisms in number is then an expression of productivity in terms of yield.

Birge and Juday (1922) have estimated that the annual production of plankton in Lake Mendota, Wisconsin is about 10,700 pounds of dry organic matter per acre. Some of the problems involved in the determination of such a crop and its significance are apparent in the following statement from these authors:

> There is no period of time during the year when one crop of plankton ceases and another begins, so that there is no definite starting point for the estimation of the annual crop of plankton, such as one finds for a land crop, for example. Neither is there any exact date of maturity, or harvest season, for the plankton crop as there is for the land crop. The crop of plankton, therefore, represents a continuous stream of life which flourishes at all seasons of the year and which passes on from year to year as long as favorable conditions obtain in a body of water.

Probably the first question that should be considered in discussing these plankton records is, what determines an "average monthly total plankton yield" of Lake Michigan in the Chicago area? Such a yield has been computed by averaging the average monthly total yields of Stations 1, 2, 3, and 4. Logically, then, the next question should be, what does it mean? Is such a figure the expression of the abundance of plankton in Lake Michigan water at the surface, at the bottom, along the shore or at a specified distance from shore? The stations range from two to nearly four miles offshore and from Wilson Avenue on the north side of the City to 68th Street on the south side, a distance of approximately fifteen miles. The depths of the various intakes in the crib wells range from eighteen to twenty-nine feet below the surface of the lake. However, some of the crib foundations are so constructed that it is possible for water to enter the well from a point in the lake nearer the surface than the depth at which the tunnel intake ports are located. Thus, it would seem that the average monthly total plankton yields of Lake Michigan as expressed at Chicago are representative of the plankton occurring in the water from near the surface to a depth of not more than twenty-nine feet. Such a statement is quite general and indicates nothing of the possible vertical distribution of the plankton in Lake Michigan water.

VERTICAL DISTRIBUTION

During the summer of 1940, the writer made several offshore collections on Lake Michigan from Evanston, Illinois. Surface and near-bottom samples were taken out as far as six miles from shore where a maximum depth of fifty-four feet was reached. Water temperatures were measured with a Negretti and Zambra reversing thermometer and light penetration with a Secchi disc.

Quantitative difference in the phytoplankton at various depths were noted but never with any consistency. On July 10, 1940, surface plankton counts were higher than near--bottom counts except at six miles from shore. On July

30, the surface collections at various points from shore averaged lower than the near-bottom collections at all points. Other trips showed still other variations. Chandler (1942b) reported similar results on western Lake Erie where the greatest abundance of the plankton may be at the surface, at a depth of fifteen feet or sometimes at depths of twenty-seven feet. These data indicate that there exists a variable vertical distribution of plankton in the upper thirty feet of water in lakes resembling Lake Erie and Lake Michigan. However, when consideration is given to the tremendous amount of water leaving Lake Michigan by the force of gravity through submerged intake Ports[5] it seems quite evident that a rather thorough mixing of lake water of various stratifications must take place. Inasmuch as the plankton collections are not made until the water reaches the shoreline pumping stations, an additional two hours of mixing is possible as the water moves shoreward through the underground tunnels. Such treatment of the Lake Michigan water would seem to counteract any specific stratification of the plankton which might have been established at the cribs. As a result, it seems reasonable to assume that the Chicago plankton collection are quite representative of the plankton occurring in the upper fifteen to twenty feet of Lake Michigan water opposite the City of Chicago.

Plankton at Chicago

The plankton yields of Lake Michigan as recorded at Chicago by the Chicago Health Department Laboratory include both plant and animal forms. The plants listed are members of the Bacillariaceæ, Myxophyceæ, Chlorophyceæ, Chrysophyceæ, Dinophyceæ, and Schizomycetes. The animal forms listed are predominantly Protozoa with occasional entries for the Crustacea and Rotifera. It should be recalled that the monthly summary (Fig. 4) was not arranged according to the above classification, but it does include representatives of the above mentioned categories. The plankton groups are discussed, however, as originally organized in the counting system initiated by the Water Purification Division.

Qualitative Results

Approximately 216 plankton genera have been reported as occurring in the water samples of Lake Michigan collected at Chicago between 1926 and 1942 (Table 4). No specimens have been preserved for checking identifications, thus, the approximate total figure is based on counting sheet entries made at the time of evaluating the plankton sample. An occasional entry of an "unidentified form" might have meant the addition of another genus to the approximate list of 216 if proper identification could have been made. However, under such conditions the unknown is represented on the records as unidentified. A list of the individual genera referred to in Table 4 may be found as an Appendix.

5 See Table 1 for crib capacities in million gallons per day.

TABLE 4.—The number of plankton organisms recorded as found in the water supply of Chicago taken from Lake Michigan between 1926 and 1942.

GROUP		NUMBER OF ENTRIES	
		Genera	Species
I	Bacillariaceae	28	30
II	Chlorophyceae	63	63
III	Protozoa	62	67
IV	Rotifera	29	29
V	Crustacea	7	7
VI	Miscellaneous		
	Myxophyceae	13	13
	Schizomycetes	2	2
	Etc.*	12	12
	Total	216	223

* See Appendix for other entries.

It should be kept in mind also that the approximate total of 216 genera is the total occurring in plankton samples which were given the standard Sedgwick-Rafter treatment in the laboratory. There is every indication to believe that the list could be increased markedly by using some other more direct means of qualitative collecting. Such a means is the tow net which concentrates the organisms from a much larger volume of water than is practical with the Sedgwick-Rafter funnel. Those interested in taxonomic lists of plankton organisms occurring in Lake Michigan should consult the literature already reviewed.

A comparative summary of records compiled from all the known plankton publications on Lake Michigan water comprises Table 5. Individual consideration has not been given the work of Briggs (1872), Thomas and Chase (1887), Birge (1881), Forbes (1882), and Skvortzow (1937) in the table; but their records have been used in composing the total number of genera and species reported as occurring in Lake Michigan to date. With the exceptions of Ward (1896), who worked in the extreme north end of Lake Michigan, and Ahlstrom (1936), who had collections from almost the entire area of the lake; all of the other publications cover data collected in the south end of the lake, mostly in the immediate vicinity of Chicago.

It is interesting to note that if the efforts of all the workers on Lake Michigan Plankton be combined a total of 363 genera and at least 784 species and varieties have been reported. No one individual has approached anything near these totals as yet. The area of the lake studied undoubtedly has a marked effect on the type of plankton found with regard to both quantity and quality. However, the real fallacy in such comparisons (Table 5) lies not in comparing the work of individuals but in comparing the number of genera and species reported without knowing specifically what they are. On the basis of the information in Table 5, it would appear that the organisms of the Lackey list approximates very closely the list of the writer (1944). However, out of the 66 species of protozoa listed by the writer only 15 or less than 23 per cent occurred in the Lackey list. Thus, in order to make proper comparisons of the

TABLE 5.—Number of genera and species of plankton organisms reported as occurring in Lake Michigan by various workers. Numerator=no. of genera. Denominator=no. of species and varieties.

Author: Date:	Ward 1896	Leighton 1907	Eddy 1927	Deyls Gerstein 1929	Ahlstrom 1936	Daily 1938	Damann 1941-43	Lackey 1944	Damann 1944	TOTAL NO. OF: GENERA	SPECIES
BACILLARIACEAE (Diatoms)	27/69	8/8	19/26	17/18	29/93	20/27	21/26	18/31	28/30	49	316
CHLOROPHYCEAE (Green algae)	7/7	6/6	16/21	12/12	20/36	11/11	29/43	44/59	63/63	83	124
MYXOPHYCEAE (Blue-green algae)	4/4	2/2	9/14	4/4	10/16	8/9	16/19	13/17	13/13	21	39
PROTOZOA	57/78	8/8	16/19	13/13	14/24	5/6	6/7	56/69	62/67	129	182
ROTIFERA	19/26	3/3	13/16	4/4	21/32	-- --	-- --	-- --	29/29	44	67
CRUSTACEA	20/30	1/1	13/20	3/3	-- --	-- --	-- --	-- --	7/7	18	37
SCHIZOMYCETES	-- --	1/1	-- --	-- --	-- --	-- --	-- --	5/5	2/2	7	7
MISCELLANEOUS*	-- --	2/2	1/1	3/3	-- --	-- --	-- --	-- --	12/12	12	12
TOTALS	134/214	31/31	87/117	56/57	94/201	44/82	72/95	136/181	216/223	363	784

* See Appendix for individual entries.

** The works of Briggs (1872), Birge (1881), Forbes (1882), Thomas and Chase (1887), and Skvortzow (1937) have not been given individual consideration in the above table; but the organisms they reported have been included in the total. This total figure represents the distinctly different genera and species reported for Lake Michigan by the various workers from all known publications.

combined efforts of all the workers on Lake Michigan plankton, a check list should be made of all species reported. Neither time nor space allow for such treatment here.

Lackey regarded his list of 181 species as strikingly small and stated that a similar number of samples from almost any stream in the Ohio River Basin would yield two to three times as many species. Tiffany (1934 and 1937) has reported 435 species and varieties, exclusive of the diatoms, desmids and protozoa, from Lake Erie. Kofoid (1908) listed 529 forms from the Illinois River through which Lake Michigan water is diverted. When it is considered that a total of over 200 genera alone have been listed herein as occurring in the area of the lake opposite the City of Chicago and that 784 forms have been reported to date for the entire area of Lake Michigan, it would seem that a wide variety of species are present but so infrequently that considerable sampling over long periods of time is necessary to insure a complete representation of the species present.

It probably should have been emphasized by Lackey in his discussion of the species reported for Lake Michigan (1944, P. 672) that the work of both Daily (1938) and Damann (1944) considered mainly the relation of the

quantitative aspects of the phytoplankton[6] to seasonal periodicity. No consideration was given to the zooplankton as a group by either worker and in the study of the writer consideration was given only to the phytoplankton organisms which were present in sufficient numbers to be important quantitatively in the development of seasonal pulses. A taxonomic list of organisms encountered at Evanston was compiled by Daily and the writer confirmed the presence of most of the organisms during the year following Daily's work. Many forms, in addition to those reported by Daily, were found in tow net collections but inasmuch as the Sedgwick-Rafter method was used exclusively in the strictly quantitative studies no consideration was given to the organisms found in the tow net collections. The fact that the zooplankton were not considered as a group at all and that only the phytoplankton organisms present in sufficient quantities to affect seasonal periodicity were considered serves to explain the rather low number of genera credited to Daily and the writer by Lackey (1944, Table 2).

QUANTITATIVE RESULTS

The diatoms very definitely dominate the plankton of Lake Michigan during every season of the year. They have accounted for 90 per cent of the plankton from 1926 through 1942 (Table 6). The Protozoa have produced

TABLE 6.—The seventeen-year average yields of the various groups of plankton organisms of Lake Michigan at Chicago, Illinois from May, 1926 through December, 1942.

GROUP	NO. OF ORGANISMS PER CC.	PER CENT OF TOTAL PLANKTON*
I Bacillariaceae	823	90
III Protozoa	53	6
VI Miscellaneous	31	3
II Chlorophyceae	10	1
IV Rotifera	—1	—0.1
V Crustacea	—1	—0.1
Total	918	100

* All figures other than the minus values are expressed to the nearest whole number.

6 per cent and a Miscellaneous group, which includes the blue-green algæ (Myxophyceæ), has been responsible for 3 per cent of this same plankton total over the seventeen-year period. The green algæ (Chlorophyceæ) accounted for 1 per cent and the Rotifera and Crustacea rarely produced significant yields.

Monthly plankton summaries often show the diatoms producing as high as 98 per cent of the total plankton during winter months. During the summer months when the other plankton groups are generally more abundant, the diatoms seldom ever produce less than 80 per cent of the total plankton. The group yields making up the total plankton yield for the inshore area of Lake Michigan at Evanston, Illinois, recorded by Daily (1938) and the writer (1941) were found in essentially similar proportions.

6 All organisms listed by G. M. Smith, *Freshwater Algae of the United States*, were considered as phytoplankton. The protozoa which contribute heavily to the plankton were not included.

Diatoms

Inasmuch as the diatoms produced 90 per cent of the total plankton, individual consideration has been given to the more abundant genera of this group of algae (Tables 7 and 8). A total of 49 genera and 316 species have been listed by various workers as occurring in Lake Michigan (Table 5). However, only 28 genera of diatoms have been listed by the City of Chicago and of these 28 only six appear to be consistent and major contributors to the annual total plankton yields.

Fragilaria has been the most dominant of all the plankton organisms occurring in Lake Michigan at Chicago. As a genus it has accounted for 34 per cent of the average total plankton and 38 per cent of the average total diatom yield. It produced the highest annual average yield of all the plankton genera consistently from 1928 through 1942. It undoubtedly produced the highest annual average yield in 1926 and 1927 as it appears that a change in counting units, as applied to Fragilaria, was made in 1928 (see page 785). Fragilaria produced the maximum monthly yield of all plankton genera for ten of the seventeen years and during this period only once did such a maximum occur as early as July. One other maximum was produced in September and during six years the maximum monthly yield was produced in November. One record maximum occurred as late as December and the other remaining one was recorded in January. As a result it would seem that Fragilaria is definitely a fall dominant of the plankton.

Tabellaria ranked second to Fragilaria in yield among the diatoms and all of the other plankton genera occurring in Lake Michigan at Chicago. It produced the highest annual average yield once (1927); ranked second during six years (1926, '28, '30, '31, '39, and '41); third during eight years (1929, '32, '33, '35, '37, '38, '40, and '42); and fourth two years (1934 and 1936). Tabellaria produced the maximum monthly yield of all the genera only twice. In 1927 such a maximum developed in July while in 1941 it did not occur until December. The annual trend of yield developed by Tabellaria fails to conform to any generally accepted pattern. It has often suggested a continuous increase of yield from spring through fall and into the winter.

Asterionella ranked very close to Tabellaria with regard to the average total plankton produced over the seventeen-year period. Each genus accounted for approximately 20 per cent of the average total plankton. Together they produced 44 per cent of the average total diatom yield. Asterionella produced the second highest annual average yield during nine of the seventeen years (1927, '29, '32, '33, '35, '37, '38, '40, and '42), and ranked third during the other eight years. The annual trend in yield consistently follows the characteristic bimodal curve generally developed by the total plankton in most temperate lakes. The spring pulse was usually terminated not later than July and the fall pulse was not initiated until late September or October.

Synedra accounted for 10 per cent of the total plankton yield and 11 per cent of the diatoms over the entire seventeen years. It produced the highest annual average yield during one year (1926), ranked second twice (1934 and

1936), and third once (1927). During the eleven other years it ranked fourth or lower. Its annual trend in yield is quite similar to that of Asterionella during the development of the spring pulse. However, in the fall Synedra often failed to develop a pulse.

All other genera of diatoms accounted for only 5 per cent of the total plankton and 7 per cent of the average total diatom yield, even though they may at times be abundant. This would seem to indicate that as a group they are probably more important in the development of monthly yields than annual yields.

On the basis of yields recorded over a seventeen-year period, Fragilaria, Tabellaria, Asterionella, and Synedra may be considered as "annual dominants" in the order mentioned. Together they have produced 83 per cent of the average total plankton and 93 per cent of the average total diatom yield. Melosira and Rhizosolenia may be considered "seasonal dominants." Together they have accounted for a little over 2 per cent of the average total plankton but both have produced dominating monthly yields. All other diatom genera accounted for 3 per cent of the total plankton. Chandler (1942) refers to the diatom genera mentioned above as being similarly abundant in western Lake Erie. Even the trend in yields of the dominant diatoms in both Lake Michigan and Lake Erie were quite similar for the year 1940. This suggests the possibility that the dominant diatoms are essentially similar in all the Great Lakes and that they probably exhibit a common periodic cycle.

TABLE 7.—A summary of the diatoms occurring in the plankton of Lake Michigan at Chicago from 1926 through 1942.

GENERA	NO. OF ORGANISMS PER CC.	PER CENT OF THE TOTAL PLANKTON	PER CENT OF THE TOTAL DIATOMS
Fragilaria	315	34	38
Tabellaria	182	20	22
Asterionella	178	19	22
Synedra	91	10	11
Melosira	13	1	1.5*
Rhizosolenia	13	1	1.5*
Other Genera	31	3	4
Total Diatoms	823	90	100.0
Other Groups	95	10	
TOTAL PLANKTON	918	100	

* All other averages are expressed to the nearest whole number.

Protozoa

The Protozoa ranked second to the Diatoms producing 6 per cent of the average total plankton over the entire seventeen years. As a group it has been dominated almost entirely by Dinobryon which may or may not substantiate the claim of Ahlstrom (1936) that Lake Michigan is a "Dinobryon Lake." Since the diatoms produce 90 per cent or more of the total plankton, Lake Michigan would seem to be primarily a "Diatom Lake" and secondarily a

"Dinobryon Lake." Ahlstrom also stated that the zooplankton was often equal to the diatom group in volume but not in numbers. According to the plankton records analyzed here,the zooplankton has never equalled the diatom in either number or volume. A rather characteristic relationship between the average monthly volume of zooplankton and diatoms is shown in Fig. 4.

As many as 26 species of protozoa have been reported by Ahlstrom (1936) as being present in the deepwater collections of Lake Michigan. Eddy (1927) reported 21 forms, the Chicago Health Department has enumerated 67 forms as occurring in the plankton samples taken between 1926 through 1942, and Lackey has listed 69 species for the south end of the lake (Table 5). In addition to the dominating Dinobryon, occasional entries are found for Ceratium, Difflugia, Vorticella, Synura, Tintinnus, and Uroglena. Other genera that have been encountered are listed in the Appendix.

Miscellaneous Organisms

The Miscellaneous group, which includes the blue-green aglæ (Myxophyceæ), filamentous bacteria (Schizomycetes), and occasional entries for the Arachnida, Bryozoa, Hydracarina, Hydrozoa, Oligochæta, Porifera, Turbellaria, Gastrotricha, Nematoda, and Vermes accounted for 3 per cent of the total plankton yield over the entire seventeen-year period. The blue-green algæ accounted for about 1 per cent of the group yield. The genera of algæ most often encountered in the collections were Chroococcus, Coelosphærium, Gomphosphæria, Merismopedia, and Microcystis. Other genera recorded have been listed in the Appendix.

Chlorophyceae

The green algæ appear to be about as abundant as the blue-green algæ and as a group have accounted for approximately 1 per cent of the total plankton during the past seventeen years. The individual constituents were never abundant but the group usually developed a minor pulse sometime during April, May, June or July. The maximum monthly average yield recorded was 100 organisms per cc in March, 1932. All other high monthly yields consistently occurred in May or June. The genera of Chlorophyceæ most often encountered were Coelastrum, Dictyosphærium, Gloeocystis, Hormidium, Nephrocytium, Oocystis, Pediastrum, Scenedesmus, and Sphærocystis. Many other genera occurring less frequently have been listed in the Appendix.

Rotifera and Crustacea

The Rotifera and Crustacea accounted for less than 0.1 per cent of the total plankton. However, it should be remembered that these comparisons in yield have been made by considering the number of organisms per cc. and not the volume of those same organisms per cc. which undoubtedly would add to the significance of both the Rotifera and the Crustacea. As a result it is believed that both of these groups contribute more to the total plankton than they have been credited with. The genera reported in the Rotifera and Crustacea are listed in the Appendix.

Annual Variations in Yields of Diatom Genera

Upon inspection of the average annual yields of Lake Michigan plankton (Fig. 5), it is evident that the total plankton yields vary considerably from year to year. The years 1926 and 1927 represent the beginning of the Water Purification Division's present program and it has been assumed that the extremely low yield of those two years, in comparison with the years that followed, was probably due to changes in methods employed. A slight change in counting units used with regard to filamentous organisms would be the only necessary alteration to account for the variation. Fragilaria seems to be the individual genus in which the greatest discrepancy is noted and it lends itself splendidly to the situation. It characteristically grows in long band-like filaments and a simple change of counting an individual cell as a unit instead of 100 microns of a filament as a unit would make the results consistent with the years that follow. It was impossible to check with the official counter of 1926 and 1927, but such an explanation certainly fits the results that followed with the Fragilaria counts of 1928, 1929, etc.

The variations from year to year in yield of diatoms are much greater than the annual variations of all the other groups combined. In fact, the yield of the composite assemblage of all groups except diatoms might be considered quite consistent from year to year. Assuming such is the case, then the diatoms are almost entirely responsible for the variation in total yield of plankton from year to year. In the discussion of these annual variations in the plankton yields, reference to "high productive" and "low productive" years indicates the relationship of the annual average yield to the seventeen-year average yield. A high productive year is one in which the annual average plankton yield is higher than the seventeen-year average yield, and a low productive year is one in which the annual average is lower than the seventeen-year average.

With two exceptions, the annual yields of the individual diatom genera were quite similar during 1926 and 1927. In 1926 the annual yield was high for Synedra and low for Tabellaria; in 1927 just the reverse was true. Thus, by comparison, both 1926 and 1927 would be considered low productive years. During 1928 and 1929 the average annual yields of the dominant diatoms closely parallel each other. The yield of the composite group of organisms, which includes all of the plankton organisms except the diatoms, decreased in 1929. However, this decrease was offset by slight increases in yield of both Asterionella and Fragilaria. Rhizosolenia and Nitzschia were responsible for the increased yield of the non-specified group of diatoms. Again by comparison, both 1928 and 1929 would be considered high productive years.

Low productive years with marked similarities in yield were encountered in 1930 and 1931. Asterionella and Synedra were responsible for the slightly higher total annual yield in 1930.

By comparison with 1930 and 1931, the years 1932 and 1933 would be called high productive years. The yields of Asterionella and Fragilaria were above average in 1932 but dropped considerably in 1933. The average annual total yield is maintained in 1933 by the occurrence of the highest yield of the composite group during the entire period from 1926 through 1942. The blue-

TABLE 8.—A summary of the average annual plankton yields of the four stations on Lake Michigan at Chicago from May, 1926 through December, 1942, expressed as number of organisms per cc.

	1926	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'42	Aver. '26-'42
DIATOMS:																		
Fragilaria	18	20	339	386	358	340	449	345	206	293	323	390	347	349	302	429	453	315
Tabellaria	150	358	283	270	189	212	89	103	101	102	97	133	130	170	166	305	244	182
Asterionella	94	101	232	304	161	89	226	122	146	117	241	146	165	154	224	248	254	178
Synedra	237	44	62	63	54	18	51	61	147	65	247	63	38	50	139	88	127	91
Melosira	15	10	13	14	9	12	5	12	6	19	9	14	15	17	9	18	19	13
All other diatoms	7	3	71	44	24	22	145	106	47	26	14	38	18	9	33	75	61	44
TOTAL DIATOMS	521	536	1000	1081	795	693	965	749	653	622	931	784	713	749	873	1163	1158	823
ALL OTHER PLANKTON	15	8	116	54	74	67	99	193	157	141	111	105	102	91	72	90	119	95
TOTAL PLANKTON	536	544	1116	1135	869	760	1064	942	810	763	1041	889	815	840	945	1253	1277	918

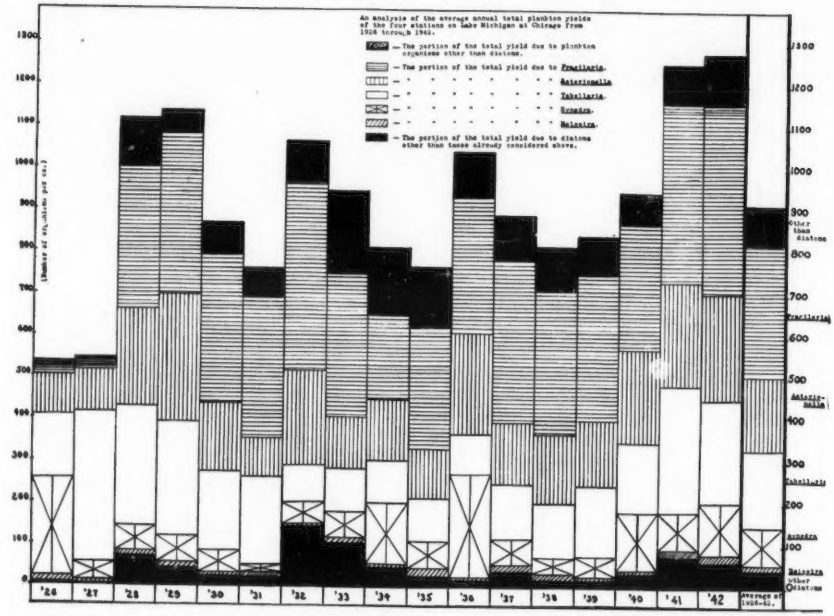

Fig. 5. Annual Plankton Yields of Lake Michigan.

green algæ plus other organisms of the Miscellaneous group were responsible for this record yield. The non-specified diatoms were also instrumental in maintaining 1932 and 1933 as high productive. The genera of diatoms responsible were Nitzschia and Rhizosolenia.

Low production occurs again during 1934 and 1935. The only evident difference in the yields of the two years is the increased yield of Synedra in 1934 which is counterbalanced by a similar increase of Fragilaria in 1935. A pronounced increase toward high production returned in 1936 and 1937 with Asterionella and Synedra responsible for the increased yields in 1936. Fragilaria, Tabellaria, Melosira, and non-specified group yields increased in 1937 over 1936 but were offset by major decreases of Asterionella and Synedra.

The yields of 1938 and 1939 parallel each other quite closely, but by comparison with the average yield of seventeen years they would be considered slightly low productive years. The only evident difference between the yields of 1938 and 1939 is the somewhat greater abundance of Tabellaria and Synedra in 1939.

High productive years occur again during 1940 and 1941 with the latter annual yield the next to the highest for the entire seventeen-year period. The increase of 1940 over 1939 resulted from the increased yields of Asterionella, Synedra, and the non-specified diatoms.

If the trend of events had followed the pattern apparently set, a low productive year should have resulted in 1942. However, conditions are quite the opposite with 1942 producing the highest annual yield for the entire seventeen years. Fragilaria, Asterionella, Synedra, and the organisms other than diatoms all showed increases in yield over 1941.

Disregarding 1926 and 1927 (see page 785), it appears that Fragilaria has produced rather consistently high average annual yields from year to year. Likewise Asterionella shows few drastic variations in annual yields. Tabellaria and Synedra appear more erratic and vary considerably over the entire period. Synedra was the major variant with an average annual high yield of 247 organisms per cc. in 1936 and an average annual low of 18 in 1931. Annual yields of Melosira were low throughout the entire period but quite consistent. The annual average yields of diatoms other than those already mentioned above showed minor pulses four times during the seventeen-year period. Rhizosolenia and Nitzschia were chiefly responsible for such spasmodic yields. It is not meant to imply at this point that if annual consistency in yield is prevalent, monthly yields will necessarily show the same consistency. Yields determined on a monthly basis usually vary considerably. Such seasonal variations in yields are to be considered in a subsequent paper.

• Data collected by the writer (Damann, 1941) indicated that individual diatom genera occurring in Lake Michigan have high and low productive years. Such variations in turn were thought to have a pronounced effect upon the total phytoplankton productivity from year to year. Chandler (1942b) stated that data from western Lake Erie confirmed the above suggestion and the seventeen years of Lake Michigan data presented here certainly substantiate further the above claim.

Apparent Biennial Periodicity of Total Plankton

The trend followed by the average annual total plankton yields of Lake Michigan at Chicago (Fig. 5) seems to be one of recurring two-year cycles. Two rather low productive years are followed by two rather high productive years. This relationship is represented graphically in Fig. 6. A very definite two-year cycle results. However, the explanation is as yet not apparent. Another possibility might be to usurp a four-year cycle with decreasing yields occurring over a four-year period. A marked increase in yield then follows during the fifth year only to diminish again and be renewed in four years (Fig. 5). However, both proposed cycles are disrupted when considering the yields of 1941 and 1942.

A striking coincidence has been noted between the expansion in the steel industry from 1935 through 1942 and the increase in plankton production of Lake Michigan in the Chicago area.[7] The significance lies not in the steel expansion of this country, but with the activity connected with all of the

[7] Time Magazine. 1943. Vol. 41(9):72.

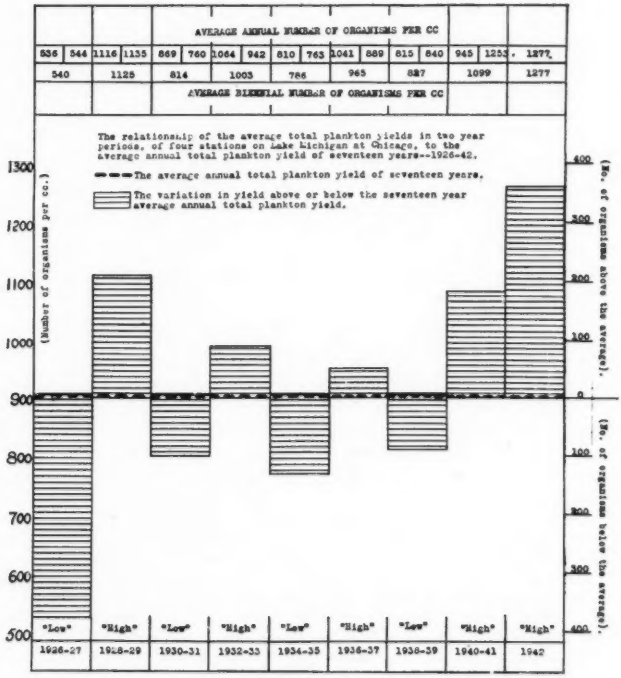
AVERAGE ANNUAL NUMBER OF ORGANISMS PER CC
836 544 1116 1135 869 760 1064 942 810 763 1041 889 815 840 945 1253 1277
540 1128 814 1003 786 965 827 1099 1277
AVERAGE BIENNIAL NUMBER OF ORGANISMS PER CC
The relationship of the average total plankton yields in two year periods, of four stations on Lake Michigan at Chicago, to the average annual total plankton yield of seventeen years--1926-42.
The average annual total plankton yield of seventeen years.
The variation in yield above or below the seventeen year average annual total plankton yield.
(Number of organisms per cc.)
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
100
200
300
400
(No. of organisms above the average).
(No. of organisms below the average).
"Low" "High" "Low" "High" "Low" "High" "Low" "High" "High"
1926-27 1928-29 1930-31 1932-33 1934-35 1936-37 1938-39 1940-41 1942

Fig. 6. Biennial Periodicity of Total Plankton.

industries occupying the southern shore of Lake Michigan. It is assumed that the expansion of the lake shore industries as well as the increased production of the same has resulted in more and more sewage entering Lake Michigan in the Calumet and Indiana Harbor. It is impossible to secure figures at this time on the activity of these industries. However, it is hardly necessary under the present war time program to produce figures in support of increased activity in the vital war industries. It is common knowledge that industries in the Calumet area are running to the capacity of the original plants and also expanding. Thus, it appears that the quantity of plankton produced in the Chicago region of Lake Michigan varies with the activity of the industries which empty their sewage and industrial wastes into Lake Michigan via the Calumet River and the Indiana Harbor Ship Canal. The best indirect evidence of such a relationship is the coliform bacterial counts indicating pollution of the water utilized by the City of Chicago. They will be considered in some detail in a later report.

Gorman (1939) in explaining the pollution problem at Dunne Crib (Station 1) from 1935 through 1938 noted a definite correlation between state of pollution and economic conditions in the Calumet area. The annual average total plankton yields seem to show a similar relationship to these economic conditions. There has been a definite increase in plankton production from 1938 through 1942 which is the period in which most industries have been undergoing the greatest expansion period ever experienced. As a result plankton production should be expected to continue increasing in the Chicago Region of Lake Michigan. In fact, plankton production should continue to increase as long as the activity in these industries increases providing the sewage is allowed to enter Lake Michigan as is customary now and it does not reach the point where it inhibits the growth of plankton.[8] Therefore, if there is any significance to be attached to the two-year cycle of plankton development (Fig. 6), it very definitely has been upset by increased pollution produced under rather unnatural conditions allowed to exist on the southern shores of Lake Michigan.

Summary

1. Seventeen years of plankton data collected from Lake Michigan by the Water Purification Division of the City of Chicago have been analyzed.

2. During this seventeen-year period, from 1926 through 1942, over 12,000 individual plankton collections have been made all of which were given the standard Sedgwick-Rafter treatment. Due to the profuse amount of data accumulated, the annual records only have been given consideration here.

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8 Data analyzed following the completion of this report show that plankton production did not increase in 1943 over 1942. In fact, the annual average total plankton yield was slightly lower for 1943 than for 1942 but it still was well above the seventeen-year average yield, and, therefore, could be considered as a high productive year. However, the first eleven months of 1944 show plankton yields far above any previous year and from all indications will produce the highest annual average plankton yield recorded between the years 1926 and 1944. The 1944 average monthly plankton yield through November was 1325 organisms per cc. Thus, it appears that plankton production has been very definitely on the increase in Lake Michigan opposite the City of Chicago between the years 1938 and 1944. Whether the effect of increased pollution was apparent or real is not known.

3. A total of 223 different organisms were reported as occurring in Lake Michigan water at Chicago. A survey of all the known publications on the plankton of Lake Michigan water yielded a list of 363 genera and 784 species and varieties. The diatoms occurred in the widest variety of forms claiming 316 different kinds. The protozoa were credited with 182 different forms followed by the green algæ with 124 forms. The remaining groups ranked as follows: Rotifera, 67 forms; Blue-green algæ, 39 forms; Crustacea, 37 forms; Miscellaneous, 12 forms; and Schizomycetes, 7 forms.

4. The analyses of the quantitative plankton records show very definitely that the plankton of Lake Michigan has been dominated by the diatoms during the entire seventeen years. They accounted for 90 per cent of the average total plankton. The Protozoa produced 6 per cent and a Miscellaneous Group, which included the blue-green algæ, was responsible for 3 per cent. The Chlorophyceæ produced about 1 per cent and the Rotifera and Crustaceæ rarely produced significant yields.

5. Of the 90 per cent of the average total plankton yield due to the diatoms approximately 83 per cent was produced by Fragilaria, Tabellaria, Asterionella, and Synedra. These genera accounted for 34, 20, 19, and 10 per cent respectively of the average total plankton yield. As a result all other diatom genera combined produced less than 7 per cent of the average total plankton yield recorded for Lake Michigan at Chicago from 1926 through 1942.

6. Even though the diatoms completely dominated the entire plankton assemblage quantitatively, the annual generic yields of diatoms tend to reflect competition among the individual genera. This competition results in high and low productive years for various genera which in turn have a pronounced effect upon the total plankton produced from year to year. The factors affecting the competition of individual genera are not yet known specifically as such.

7. The graphic expression of the average annual total plankton yields of Lake Michigan suggest the occurrence of a periodic biennial cycle in which two rather high productive years are followed by two rather low productive years. A modified four-year cycle is also suggested. However, both proposed cycles are interrupted when consideration is given to the extremely high average total yields of 1941 and 1942. An explanation of these cycles is as yet not apparent but the effect of industrial and domestic pollution in southern Lake Michigan is suspected.

8. Plankton data of 1943 and 1944 analyzed following the completion of the main portion of this report further substantiate the earlier claim (p. 44) that plankton production has been increasing in Lake Michigan opposite the City of Chicago since 1938. The specific effect of increased pollution occurring in the southern end of the lake on the quantitative increase of the plankton at Chicago is not known. However, it is known that during the period while plankton production has been increasing (1938-44), the state of pollution in the Calumet and Indiana Harbor areas of Lake Michigan has been becoming more and more severe.

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Appendix

PLANKTON ORGANISMS REPORTED AS OCCURRING in the CHICAGO PUBLIC WATER SUPPLY 1926 — 1942*

No attempt has been made here to compile an extensive taxonomic list of all the plankton organisms actually occurring in Lake Michigan at Chicago, Illinois. Only those organisms recorded as having occurred in the plankton samples, which are given the standard Sedgwick-Rafter treatment, have been listed. In the majority of instances, genera only are enumerated and all determinations by the Chicago Health Department Laboratory have been referred to the following publications:

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* Compiled from Water Purification Division, Plankton Reports, October 20, 1944.

The writer in going over the Water Purification Division records has assumed full responsibility for the interpretation of all entries of organisms made and the categorizing of the same. Duplication of entries due to synonymy has been recognized and corrected where possible. When the same organisms appeared to be represented by more than one entry, the more acceptable name has been listed first and then followed by the synonym in parentheses as follows: Cymbella (Cocconema), Lagerheimia (Chodatella).

The categories recognized in this listing and the number of entries for each group are as follows:

Group	I Bacillariaceæ	30
"	II Chlorophyceæ	63
"	III Protozoa	67
"	IV Rotifera	29
"	V Crustacea	7
"	VI Miscellaneous	27
	Total	223

PLANKTON ORGANISMS REPORTED AS OCCURRING IN THE CHICAGO PUBLIC WATER SUPPLY 1926 - 1942

GROUP I BACILLARIACEAE

Amphilpleura
Amphiprora
Amphora
Asterionella
Campylodiscus
Cocconeis
Cyclotella
Cymatopleura (Sphinctocystis)
Cymbella (Cocconema)
Denticula
Diatoma
Epithemia (Cystopleura)
Fragilaria
Gomphonema
Gyrosigma
Melosira (Lysigonium)
Navicula
Nitzschia (Homoeocladia)
Pinnularia
Pleurosigma (Sigmapleura)
Rhizosolenia
Rhoicosphenia
Rhopalodia
Stauroneis
Stephanodiscus
Surirella
Synedra
Synedra radians
Synedra ulna
Tabellaria (Striatella)

GROUP II CHLOROPHYCEAE

Actinastrum
Ankistrodesmus
Arthrodesmus
Asterococcus
Botryococcus (Ineffigiata)
Binuclearia (Planktonema)
Bumilleria
Characiopsis
Characium
Chlorangium
Chlorobotrys
Chlorosarcina (Chlorosphaera)
Cladophora
Closteriopsis
Closterium
Coelastrum
Cosmarium
Crucigenia (Staurogenia)
Dactylococcus
Desmidium

Gymnozyga
Hormidium
Kirchneriella
Lagerheimia (Chodatella)
Micratinium (Richterella)
Monocilia (Aeronema)
Nephrocytium
Oedogonium
Oocystis
Ophiocytium
Dichotomosiphon tuberosus
Dictyosphaerium
Dimorphococcus
Elakatothrix
Eremosphaera
Franceia
Geminella
Genicularia
Gloeocystis
Golenkinia
Gonatozygon
Gonium
Palmella
Pandorina
Pediastrum
Penium
Peurococcus (Protococcus)
Scenedesmus
Schizochlamys
Selenastrum
Sphaerocystis
Sphaerozosma
Spirogyra
Spondylosium
Spondylomorum
Staurastrum
Stigeoclonium (Myxonema)
Stylosphaeridium
Tetraedron (Polyedrium)
Tetraspora
Tribonema
Ulothrix
Volvox

GROUP III PROTOZOA

Acineta
Actinobolina (Actinobolus)
Actinolophus
Actinophrys
Actinosphaerium
Amoeba
Amoeba proteus
Arcella
Aspidisca
Carchesium
Ceratium hirundinella
Chilodon caudatus
Clathrulina
Codonella
Colpoda
Corycia
Curcurbitella
Cyclanura
Dallasia
Dendrosoma
Derepyxis
Derepyxis amphora
Difflugia
Dinamoeba
Dinobryon
Epipyxis
Epistylis
Euglena
Euglena viridis
Euglypha
Frontonia
Gastrostyla
Glaucoma
Glenodinium
Halteria
Hyalosphenia cuneata
Lionotopsis
Lionotus
Mallomonas
Monas
Nassula ornata
Nebela
Nuclearia
Ophrydium
Paramecium
Peridinium
Perispira
Podophrya
Raphidiophrys
Sphaerophyra
Sphaerophrya magna
Stentor
Stentor igneus
Stichotricha
Synura
Tetradinium
Thuricola
Tintinnidium
Tintinnus
Tokophrya
Trichodina
Trichophrya sinuosa
Uroglena
Uroglenopsis
Vampyrella
Vorticella
Zoothamnium

GROUP IV ROTIFERA

Anapus ovalis
Anarthra
Anuraea
Ascomorpha
Asplanchna
Brachionus
Cochleare
Colurus grallator
Conochilus
Cyrtonia tuba
Diaschiza hoodii
Diglena rostrata
Diplois daviesiae
Diurella
Euchlanis
Floscularia
Furcularia
Gastropus stylifer
Notholca longispina
Notommata
Notops
Philodina
Ploesoma
Polyarthra
Rattulus
Rotifer
Synchaeta
Tetramastix
Triarthra (Filina)

GROUP V CRUSTACEA

Bosmina
Canthocamptus
Chydorus
Cyclops
Daphnia
Diaptomus
Leptodora

GROUP VI MISCELLANEOUS

Arachnida:
  Macrobiotus
Bryozoa:
  Fredericella sultana
  Plumatella
Gastretricha:
  *
Hydracarina:
  Axonopsis
Hydrozoa:
  Hydra
Nematoda:
  *
Oligochaeta:
  Aeolosoma
  Chaetogaster
Porifera:
  Spongilla novae
Myxophyceae:
  Anabaena
  Aphanocapsa
  Aphanorapsa
  Chroococcus
  Coelosphaerium
  Cylindrospermum
  Gloeocapsa
  Gloeothece
  Gomphosphaeria
  Merismopedia
  Microcystis (Clathrocystis)
  Nodularia
  Nostoc
  Oscillatoria
Schizomycetes:
  Beggiatoa
  Crenothrix
Turbellaria:
  *
Vermes:
  Anguillula

* No specific genera listed.

Some Host Plants of Comandra umbellata in Colorado

H. D. Harrington

The genus *Comandra* contains species that are partial parasites attaching their underground parts to those of other plants by means of holdfasts. As shown by Woodcock and Zeeuw (1920), and Moss (1926) this connection is an intimate one resulting in the close intermingling of the vascular tissue of the parasite and host.

The common species of bastard toad flax in our region, *Comandra umbellata* (L.) Nutt. (*C. pallida* A. DC. is considered as a synonym here), is itself an alternate host of a stem blister rust affecting pines (*Cronartium Comandrae* P. K.). This disease attacks lodgepole pine and rock or ponderosa pine among others, especially in their younger stages and may result in the loss of a high percentage of the native or forest tree nursery stock.

One of the most obvious means of controlling this disease would be the eradication of patches of Comandra growing near the tree seedlings. As reported by Moss (1926) and suggested by transplant experiments in the present study Comandra will soon die when grown by itself, unattached to any other plant. Information as to the plants attacked therefore becomes of practical importance, since eradication of all possible host plants would automatically eliminate the bastard toad flax.

It is the purpose of the present study to add to the recorded list of these host plants. Hedgecock (1915) reported 50 species of plants upon which *Comandra umbellata* (L.) Nutt. was attached. Fisher (1922) found *Comandra pallida* A. DC. parasitizing apple, peach, *Artemisia tridentata, Lupinus suksdorfii,* and *Achillea millifolium.*

Moss (1926) found *Comandra richardsiana* Fern. on grasses, *Fragaria, Aster,* and *Rhus typhina.* He also reported *Comandra livida* Rich. parasitizing species of *Ledum, Picea, Salix, Betula, Alnus, Ribes,* and *Lonicera.* Lodgepole pine, a most convenient host, was also found affected. Brooks (1937) studied the hosts of *Comandra pallida* A. DC. in Kansas and listed *Yucca glauca, Leptoglottis nuttallii, Psoralea foribunda, Cornus asperifolia, Ulmus americana,* and *Bouteloua curtipendula* as previously unreported host species.

Very careful digging is necessary to determine the actual attachment as the toadflax readily breaks away from its holdfast, leaving this on the host. Fortunately the presence of these characteristic holdfasts can be taken as evidence of attachment. The following species of host plants were collected in eastern Colorado and specimens are in the herbarium of the Colorado Agricultural and Mechanical College:

Actinella fastigiata A. Nels.
Agropyron smithii Rydb.
Ambrosia psilostachya DC.
Andropogon hallii Hack.
Andropogon scoparius Michx.
Aragallus albiflorus A. Nels.
Argemone intermedia Sweet
Aristida fendleriana Steud.
Artemisia frigida Willd.
Astragalus drummondii Dougl.

Astragalus pectinatus Dougl.
Astragalus tridactylicus Gray
Bouteloua curtipendula (Michx.) Torr.
Bouteloua gracilis (H.B.K.) Lag.
Calamovilfa longifolia (Hook.) Scribn.
Cercocarpus parvifolius Nutt.
(*C. montanus* Raf.)
Cirsium undulatus (Nutt.) Spreng.
Eriogonum alatum Torr.
Eriogonum campanulatum Nutt.
(*E. brevicaule* Nutt.)
Eriogonum effusum Nutt.
Eriogonum subalpinum Greene
Erysimum asperum DC.
Eurotia lanata (Pursh.) Moq.
Euphorbia Greenii Millsp.
Evolvulus pilosus Nutt.
Gaura coccinea Pursh
Gilia spicata Nutt.
Gutierrezia sarothrae (Pursh) B. and R.
Helianthus pumilus Nutt.
Hymenopappus arenosus Heller
Lavauxia brachycarpa (Gray) Brit.
Liatris punctata Hook.
Malvastrum coccineum (Pursh.) Gray
(*Sphaeralcea coccinea* (Nutt.) Rydb.)
Opuntia polycantha Haw.
Paronychia jamesii T. & G.
Petalostemon purpureus (Vent.) Rydb.
Prunus melanocarpa (A. Nels.) Rydb.
Psoralea tenuifolia Pursh
Ratibida columnaris (Sims.) D. Don.
Rhus trilobata Nutt.
Sitanion hystrix (Nutt.) J. G. Smith
Stipa comata Trin. & Rupr.
Thelesperma gracile (Torr.) Gray
Townsendia grandiflora Nutt.
Tragopogon pratensis L.

In the preceding list of 45 species only *Bouteloua curtipendula* has been previously reported as a host plant for any species of Comandra. These hosts are members of 17 plant families, the Gramineae and Compositae accounting for almost one-half the total. All but 5 of the 17 families represented are new records for host plants.

No striking effect of this parasitism was noted on the host plants. Affected plants were not noticeably stunted as compared with unaffected plants of the same species growing near.

Comandra was found attached to every perennial plant growing in any abundance near it. In some species the holdfasts were very numerous on the roots while in others they were scarce. Some plants, such as *Tragopogon pratensis*, seemed immune at first but further study always indicated a few records of attachment.

No annual plant was found to be a host plant for *Comandra umbellata*. However, on the basis of the results so far the suggestion is made that there is probably no specificity at all in regard to the attachment of this parasite on any Colorado species of perennial plant.

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Notes and Discussion

Instability in Scientific Names of Plants

A. C. Martin

There seems to be considerable oversight of the fact that the primary purpose and justification for scientific names is their effective functioning as practical tools. Botanists of all kinds as well as many other scientists are faced with the unavoidable necessity of working with plant names as tools so the problem of nomenclatural instability is properly one of widespread concern. The frequent replacement of familiar old names by strange new ones has been a serious impediment to thousands of workers in botany and related fields and the resulting waste is no credit to botanists or to botanical science. Under the circumstances it seems both remarkable and regrettable that users of plant names have been as relatively passive as they have been. Revival of this uninspiring topic is occasioned partly by the unabated state of nomenclatural confusion but even more by past failure to emphasize certain fundamental principles in the use of plant names.

An analysis of the problem shows two main causative factors. One is a matter of attitude and the other of organization.

A basic source of nomenclatural trouble is defective perspective that concentrates its attention on the past. A consequence of this backward focus is an inclination to allow the means to transcend the importance of their original purpose. Certain of the rules which doubtless had a positive value at the time of their adoption have since become liabilities by promoting instead of preventing instability. Also as part of this retrospective viewpoint, it has become customary to regard scientific names as historical memorials; often in questions of priority the all-important matter of efficiency-in-use is forgotten in the issue of whether this botanist or that one deserves an epitaph. It would appear that the prevalent attitude is less concerned with practical utility of names than it is with careful conformity to traditions and the historic past.

No system of names can be satisfactory if it lacks reasonable stability. Rigid inflexibility is not only unattainable but also undesirable since changes in some well-established names are occasionally needed as accommodation to improved concepts in phylogeny or to desirable advances in standardization. Only these two causes for change, however, seem to deserve logical sanction in upsetting fixed features of the nomenclatural system. Other reasons for change usually violate the basic principle that names are simply a means to an end—they conflict with the theory that all arrangements and rules should serve to make names more practical and efficient as useful tools for modern science.

Change in a single name that has become established in usage is a complex and destructive matter. Commonly it necessitates adjustments in hundreds of thousands of recordings. A major part of the adjustment must occur in the minds of botanists or other scientists but many more thousands of revisions are required in copies of floras and other books and many additional thousands on herbarium sheets and on numerous other kinds of plant product recordings. A single name change produces an almost infinite chain of chaotic consequences. Yet numerous and often seemingly-unwarranted changes continue to be advocated without restraint.

The common sense crux of the matter seems to be this: Once a name has been firmly established in widespread or general use for say, 10, 50, or 100 years or more, questions of its validity, legitimacy, priority, form of original spelling or possibly even the correctness of the original identification should be regarded as comparatively inconsequential since they have no relevance (except in a negative way) to efficiency in modern use. Viewed from the practical standpoint, the source, origin or other past-history characteristics of an *established* name is of no real importance as compared to its present stability. Why then should an active, living majority of many thousands or even millions surrender to an extinct minority of one? Why, for example, should a tremendous number of recordings, mental and inscribed, be changed even though the original spelling of a specific name involved a mistake and omitted the customary double *N* in Pennsylvania?

Or, after many years of satisfactory use of the familiar names *Quercus prinus* and *Quercus michauxii* for two distinct species of oaks, why should we tolerate the creation of enduring confusion by the partial reversing of these time-honored names?

The wasteful harm done by the hundreds of such changes appears to have no compensatory value whatever and yet disinterred trivia continue to occupy a prominent place in current botanical literature. These exhumations, often the product of much diligent research into antiquity, help to keep nomenclature in a turmoil of confusion and if even a fraction of the interest, energy and time expended on them were applied constructively in the opposite direction, namely stabilization, the name-change situation would probably not be so acute.

The other principal contributory factor, additional to lost horizons, is the lack of a representative national organization having authority and opportunity to serve as a stabilizing foundation. There is need for a well-financed (by subscription or endowment), non-honorary nomenclatural board having its membership determined by democratic process and representing not only taxonomy but also other name-using botanical activities. It would seem that only through such a medium can there be hope of terminating the present reign of confusion.

Principal duties of the board should include maintenance of nomenclatural perspective at a practical, modern level and promotion of stability insofar as possible. The latter might be accomplished in considerable part by supplementing for North American species and also for certain native genera, the stabilizing conservation of names initiated by the International Botanical Congresses. Generic and specific names that, in the judgment of the board, seem to deserve it might be conserved in a national checklist. As a prerequisite of such action, however, the lists of such names contemplated for conservation should be published some time in advance and also there should be effort to obtain prior approval from the International Botanical Congresses. The current lack of a suitable scientific name reference covering plants in all parts of the country, plus the lack of nomenclatural agreement among standard floras, plus additional confusion contributed by taxonomic exhumings in recent journals makes the proper use of botanical names a difficult, unwelcome and time-wasting puzzle—especially for those of us who are not expert taxonomists.

A national listing, revised periodically, would not only obviate most of the present inefficient groping for suitable names but it could also perform an additional important service by providing an authentic single source for complete author and literature citations. This should, it would seem, eliminate the time, space and money wasting need for such citations in miscellaneous scientific writings with the possible exception of relatively rare instances wherein the name c[illegible]oncept it represents may not be distinct without the author citation. These citations, as commonly recorded, are inadequate as references since often they fail to give the original medium and time of publication, yet the prevailing attitude seems to be that scientific names are not truly scientific without them. It is a fortunate inconsistency that this viewpoint has not dominated the oral use of names.

Though the domain of the board would necessarily be circumscribed geographically its outlook would need to be international and cooperative rather than provincial. In representing the practical interests of name-users in this country it could be given the responsibility of exerting pressure to correct those international regulations that hinder rather than help. In instances wherein the viewpoint of the international rules seems out-of-date, impractical or otherwise undesirable, the board might serve as an effective agent in implementing the needed reforms. In addition it could serve as a clearing house and referee on name problems of both national and local significance.

In order to help assure materialization of a suitable nomenclatural organization to curb the prevailing chaos it is suggested that positive steps be taken in this direction. Accordingly it is proposed that at the earliest opportunity the Botanical Society of America appoint a promotional committee to plan details of ways and means. Until some such action as this is initiated it is probable that reform will continue to be a topic of discussion rather than a matter of reality.

U. S. FISH AND WILDLIFE SERVICE,
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Book Reviews

A Source-Book of Biological Names and Terms. By Edmund C. Jaeger. Charles C. Thomas, Springfield, Ill. 1944. xxvi + 256 pp., 96 figs. $3.50.

Biological terminology and nomenclature are mainly, though not exclusively, of Greek and Latin origin. This condition either proves to be a blessing or a curse to the student depending upon his educational background and interest. Too often students learn terms and names without understanding their full meaning and are prone to forget them promptly. On the other hand, the teacher can not always take time out to explain the terms used if he wants to cover the subject matter at hand. Thus students and others interested in biological terms and names must look for explanations elsewhere.

Although standard dictionaries contain many scientific terms and names, they must obviously fall short of completeness. Available biological dictionaries, by comparison, are mostly concerned with definitions and, to a lesser extent, with etymology, combining forms, etc. It is in this respect that the *Source-Book* will prove most valuable, containing as it does some 12,000 elements and many more examples illustrating their use. The introductory chapters on "How Words are Built" and "Types of Names Considered" will be informative and stimulating reading for all.

The author rightfully castigates biologists, notably insect-anatomists and ecologists, for originating so many "ill-coined terms," which prove them "to be word-butchers of the meanest sort." He might find consolation in the fact, that comparatively few of these terms are widely accepted. However, the story of biological names is different, since validly published ones must be used even if they are poorly constructed or lack apparent meaning.

There can be no doubt that the author has consulted many and varied sources, some of which are mentioned in the preface. A list of these references comprising sources, dictionaries, etc., could profitably be added in a later edition. The following among others should be included: Clements, F. E., 1902—Greek and Latin in Biological Nomenclature, University Studies, University of Nebraska, 3(1):1-85; medical, botanical, and zoological dictionaries, dictionaries of plant names, etc.

Anyone using biological literature will find this handy volume a real aid and soon place it with his indispensable books.—Theo. Just.

Bovine Trichomoniasis. By Banner Bill Morgan. Burgess Publishing Co., Minneapolis, Minnesota. 1944. iii+150 pp., 4 plates, 1 photograph and 24 tables. $3.25.

The principal portion of this exhaustive monograph is composed of thirteen chapters, namely, 1) Introduction, 2) Morphology and life cycle, 3) Isolation of *Trichomonas foetus*, 4) Cultivation, 5) Symptoms and lesions, 6) Diagnosis, 7) Serology, 8) Immunity, 9) Hydrogen-ion concentration, 10) Animal experimentation, 11) Prevention and Control, 12) Miscellaneous and 13) Appendix which is a host-parasite list for various trichomonads. By far the greater part of this presentation consists of a very careful survey of the information concerning bovine trichomoniasis which together with the experiences and information gained by the author makes it the most complete treatment of the subject yet to appear in this part of the world. Despite the fact that the book is largely based on a review of the literature, too much praise cannot be given the author for such a careful and clear organization and presentation of the subject. The reviewer warmly agrees with the author of the foreword in the statement "We predict that this monograph will occupy an important place in the literature and will be greatly appreciated as a ready reference by workers in the field of microbiology and especially by those interested in the highly important subject of bovine infertility."

The author readily admits that "In a monograph of this kind errors will be found despite every effort to eliminate them—" however they are few and attest to the thorough way in which the work has been done. Personally the reviewer feels that the style of

literature citation in the text together with the numbering of alphabetically arranged references in the bibliography, is a waste of time, ink, and paper but this is a matter of preferential style and is not serious. Misspelled words are very infrequent though additional punctuation would contribute much to clarity of a few statements.

Dr. Morgan is to be congratulated on the magnificent job he has done. Without a doubt veterinarians as well as various workers in the field of zoology will find his publication of real value and no library attempting to cover zoological literature should be without it.—JOHN D. MIZELLE.

AN INTRODUCTION TO ORNITHOLOGY. By Harry W. Hann. Edwards Brothers, Inc., Ann Arbor, Michigan, 1945. Pp. 6+xviii+279, many figs. (lithoprinted). $3.25.

ORNITHOLOGY NOTEBOOK. By Harry W. Hann. Edwards Brothers, Inc., Ann Arbor, Michigan, 1945. Pp. 45 (lithoprinted). $1.25.

These books were prepared as a text and record of study to be used by college students in southern Michigan, but the author expresses the hope that other persons will find the work useful. His plan is to revise and print the volume when that is possible. Purpose of the publication is to bring together in a single volume material from many sources suitable as a background in ornithology. The eighteen pages of Part I of the Introduction treat sketchily the organ systems, migration, nesting, distribution, conservation, wildlife refuges, economic importance, and attracting birds. Part II is a brief review of the birds of the world, with emphasis on North American species. Western species are treated as well as eastern ones and mention is made of the subspecies, but no attempt is made to bring this phase of the treatment up to date. This compilation would be a useful reference for many persons outside the classroom.

The Notebook is a condensed syllabus for brief study of the bird skeleton, for characteristics of orders and families, for the morphological examination of an English sparrow, and for work in the field. This section contains hints for taking notes and directions for making a special study of a nest.

Persons, in groups or singly, who use this text or any other book in bird study should discover early that the books are most useful as reference. The chief advantages in ornithology as a study are that knowledge can be acquired directly from the birds discovered and examined alive out of doors. Direction of questions toward whatever bird appears immediately arouses interest, and this interest, once aroused, almost always continues to expand. The critical stage in establishing this interest is the earliest one. In the field class if the leader helps the beginner to direct powers of perception effectively toward the bird under observation, his work is practically completed. Primary concern might well be aimed at developing clear seeing, hearing, and thinking. Learning to know one bird—its characteristics, where it lives, and what it does—could easily outrank a less thorough acquaintance with a long list. Used to supplement learning by this spontaneous response to living, free birds, Professor Hann's book provides may desirable kinds of aid. The clues he cites from the work of John Burroughs on page 31 of the notebook have special significance.—JEAN M. LINSDALE.

INJURY AND DEATH OF BACTERIA BY CHEMICAL AGENTS. By Otto Rahn. Biodynamica Monograph No. 3. Biodynamica, Normandy, Missouri. 1945. 183 pp., 34 figs. $3.50.

The present monograph—separately issued and well-bound—is essentially a reprint from Biodynamica No. 86, 1943, and No. 96, 1945. In the three parts of the book Rahn devotes approximately equal space to the logarithmic order of death, disinfectants, and antiseptics. The thesis is developed that rate of death is logarithmic in unicellular organisms and therefore death is due to the inactivation of a single molecule in each cell. This conclusion—which is "absolute" (p. 39)—is contingent upon the bacteriologist's definition of death as failure to reproduce. Rahn uses considerable data on survival curves to support his view that death is logarithmic.

The theory that enzyme inactivation is a cause of death is not tenable, according to Rahn, because present estimates show that many enzyme molecules are present in each cell. Thus, by the law of mass action, enzyme inactivation proceeding at the same rate

in each cell would result in an initial lag period and a death rate curve showing a graded resistance to death. Only by the inactivation of a single molecule per cell can the logarithmic death rate of bacteria be explained.

Rahn's presentation is logical and the reader may well find his conclusion acceptable. However, there are several points which may be in question. First, not all biologists agree that the mortality curves are truly logarithmic. Second, granting that death is logarithmic, cells may possibly have some characteristic giving them an exponentially graded resistance. Third, the question arises, must the fact that unit cells behave as unit molecules necessarily indicate an identity of relationships. Rahn has counter arguments to the first and second points but he does not consider the last one nor does he discuss the problems of definition and behavior of large organic molecules in general.

Parts II and III contain an excellent presentation of the modes of action of disinfectants and antiseptics. Recent work is well represented and many older viewpoints are critically reviewed. In particular Rahn castigates the use of the phenol coefficient for its inadequacies as a standard and proposes a new method for the expression of death time for any concentration of the disinfectant directly. The proposed method has much to recommend it. Furthermore, it is pointed out that since antiseptics chiefly retard multiplication rather than cause death, their efficiency cannot be accurately expressed by techniques used with disinfectants.

The author must be highly commended for his success in reducing a considerable amount of scientific findings to a few systematic principles concerning the effect of chemicals on injury and death of bacteria. He has brought a unity to these problems not achieved by any other known to the reviewer. His thesis, right or wrong, may well mark a milepost in the search for understanding of cell death and injury.

—NOE HIGINBOTHAM.

THOMAS JEFFERSON AND THE SCIENTIFIC TRENDS OF HIS TIME. By Charles A. Browne. Chronica Botanica, vol. 8, no. 3:363-423. 1944. Chronica Botanica Co., Waltham, Mass. $1.25.

What any prominent man thinks on any subject is news today. The opinions of a young president of a large university on almost any subject are of sufficient interest to find expression in our most popular magazines. It is of even more interest, then, to read the opinions of Thomas Jefferson, one of our most revered statesmen, on scientific questions of his time, particularly since Jefferson has been regarded as something of a scientist himself and also because of the historical aspect involved in the scientific controversies of the 18th and early 19th centuries.

The purpose of this study is revealed by the author, "In the present contribution the aim of the writer has been to describe some of the relations of Jefferson to the scientific movements of his period, and in so doing he has illustrated his descriptions by extensive quotations from Jefferson's own writings."

Jefferson's misconceptions are brought to light along with his theories that were in advance of his time. His refusal to accept Lavoisier's nomenclature, Jussieu's classification, and other errors are revealed along with his observations of the impoverishment of soil by repeated tobacco crops (before the time of soil analysis) and the value of legume cover crops and rotation (before nitrogen-fixation was demonstrated).

Jefferson observed and recorded also some notes on plant ecology, in which he was particularly interested. He noted the fact that the hardiness of a plant and its fruit was not correlated, a palm could grow in climates too rigorous for it to produce good fruits, whereas other plants, of more tender character and restricted in zonation, matured their fruits with regularity.

As an educator Jefferson has left a famous monument: The University of Virginia. Before the founding of the university, however, he had been interested in the education of American youth. Particularly pertinent today are his words, "We have spent the prime of our lives in procuring them (the young men) the precious blessing of liberty. Let them spend theirs in showing that it is the great parent of science and of virtue; and that a nation will be great in both, always in proportion as it is free."

Among the most interesting of the phases of Jefferson's life as related in this

contribution are his activities in connection with the famed Lewis and Clark expedition. An old map of the expedition is included, in addition to other maps and figures.

There is a list of references at the end of the book, plus a few well-phrased quotations from Jefferson on science.—NOE HIGINBOTHAM.

PLANT GROWTH. By L. Edwin Yokum. The Jacques Cattell Press, Lancaster, Pa., 1945. 203 pp., 16 pls., 25 figs. $3.00.

Written for the layman with practical applications of botanical principles, this treatment of botany covers such subjects as soil, roots, stems and buds, propagation, food making, balance of root and shoot, hybridizing plants, and heredity and variation in plants, besides more technical chapters on cell structure and protoplasm, and leaf structure. Although it is a difficult matter to present a complete botany so that the layman can understand such phases as reduction division, this book probably succeeds as well as possible. It is not written in too technical language—the material in most cases is presented simply enough—but it attempts to cover a large part of the botanical field, a field too fallow for most amateurs to plow through readily.

The author should, perhaps, be commended for even attempting such an explanation of scientific principles to the layman when his difficulty is apparent in the books he lists as references at the end of each chapter, e. g., Sharp's "Introduction to Cytology," Sinnott and Dunn's "Principles of Genetics," etc. Good examples are given throughout the book on the effects of botanical phenomena on familiar plants, such as the tenderness of rapidly grown asparagus. There is a fair index to the book.—NOE HIGINBOTHAM.

Walker Prizes in Natural History, 1946, for Essays on Insects

Two prizes, founded by the late Dr. William Johnson Walker, are offered annually by the BOSTON SOCIETY OF NATURAL HISTORY for the two most acceptable papers written in the English language on a subject chosen by the Board of Trustees of the Society.

PRIZES: A prize of sixty dollars may be awarded to the author of the best essay. This award may be increased to one hundred dollars, at the discretion of the judges of the contest, in the case of a paper of exceptional merit. A second prize of fifty dollars will be given only if the next best paper seems worthy of the distinction. No prize will be awarded unless the papers submitted are deemed worthy by the judges.

ELIGIBILITY: The competition for these prizes is not in any way restricted.

SUBJECT MATTER: Each paper must be the result of original and unpublished research personally conducted by the author and accompanied by an accurate bibliography and a review of general literature on the subject. All papers must be typewritten and in complete form for publication. Other things being equal, preference may be given papers showing evidence of preparation especially for this competition.

AUTHORSHIP: Each paper must be anonymous. It must bear a pseudonym placed in a conspicuous place on the first page. A sealed envelope, also inscribed with this pseudonym, must accompany the manuscript. The contents of this envelope will divulge the identity and address of the author. Anything in the essay which shall furnish proof of the identity of the author shall be considered as debarring the paper from competition.

CLOSING DATE: All competitors must submit their work to the Acting Secretary, Boston Society of Natural History, 234 Berkeley Street, Boston, Massachusetts, before May 1, 1946.

The Society and the judges assume no responsibility for publication of the winning papers. However, it is understood that authors should not publish their papers until after the announcement of the prize awards at the Annual Meeting of the Society in October, 1946.

Margaret Baker, *Secretary*

BOSTON SOCIETY OF NATURAL HISTORY,
234 Berkeley Street, Boston, Massachusetts,
October, 1945.
Subject for 1947: *Any subject in the field of Fungi.*

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